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PLATE I.

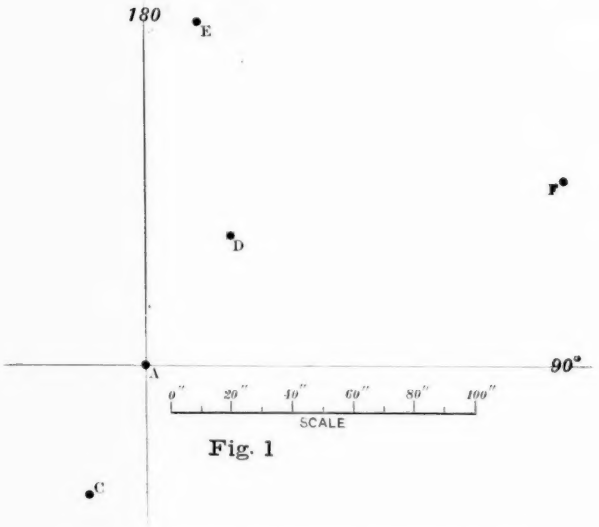

Fig. 1

β 107 AND ADJACENT STARS FROM MEASURES IN 1898.

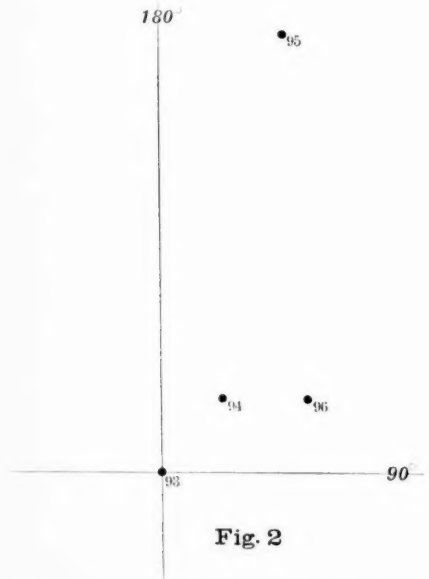

Fig. 2

β 107 AND ADJACENT STARS FROM THE D.M. POSITION.

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THE DOUBLE STAR, β 107.

S. W. BURNHAM

FOR POPULAR ASTRONOMY.

On September 7, 1873, a pair of small stars, about 25′ north of κ Cassiopeiæ was picked up with the 6-inch refractor, and entered subsequently as No. 107 of my Third Catalogue (*Monthly Notices*, December, 1873). For some reason this pair was not measured by Dembowski, and it received no further attention until I measured it in 1891 with the 36-inch at the Lick Observatory. I have recently made another set of measures with the 40-inch at the Yerkes Observatory. Finding a large difference in the two observations referred to, I examined my original estimate of twenty-five years ago, and found the change was confirmed by the record made at that time. These observations are as follows:

	°	″				
1873.68	360±	2±	9	10		β
1891 52	358.8	4 44	8.0	..... 9.6	2*n*	β
1898.72	354.0	5.67	9.1	..... 9.4	3*n*	β

It would be assumed in the first instance that any change in a pair of very small stars, separated by so great a distance, would be due to the proper motion of one or the other. In this instance the two sets of measures give an apparent annual movement of the companion of 0″.18 in the direction of 337°.3. Carrying this back to 1873, the smaller component at that time would be 1″.87 from the primary in the position-angle of 37°.7. This agrees well enough with the estimated place so far as the distance is concerned, but the agreement with the estimate of the angle is not very satisfactory. It is more difficult to judge of the direction of one star from another in high northern declinations, unless special care is taken, and this may explain the large error, if this is an error. In addition to this, allowable errors in the measures would change the direction of motion and give a much smaller position-angle for 1873. The probabilities are that the movement is rectilinear, and due to the proper motion of one of the stars, but of course there is nothing to indicate which one is drifting, beyond perhaps a slight presumption in favor of the

brighter. The difference in magnitude, however, is too small to make this of much importance.

At the time of finding this pair, I assumed that it was D. M. (62°) 93 from its situation with reference to two stars of similar magnitude in the same field and nearly south of the double, which appeared to be Nos. 94 and 95 of that catalogue. The position of the double (1880) was given:

R. A.	0h	24m	28s
Decl.	+	62°	41′

Since making the last measures, showing change in the components, I have more carefully examined Argelander, and find that the stars in the D.M. do not correspond at all to the present positions of the stars in this vicinity. In order to compare the two accurately, I have connected the four principal stars in the field with *A* of the double by micrometrical measures. The results are as follows:

	°	″			
AC	336.2	46.95	.....8.2	2*n*	1898.73
AD	146.6	50.27	.....8.3	2*n*	1898.73
AE	171.2	113.78	.....8.5	1*n*	1898.76
AF	113.9	150.44	.....8.7	1*n*	1898.76

There are many small stars in the field, but all too faint for the D. M. These five stars are laid down to scale on Fig. 1 from the above measures. The four stars given in Argelander (Nos. 93 to 96) are platted on the same scale, and shown in Fig. 2. It will be seen that it is impossible to identify the stars in one diagram with those of the other, except that *E* and No. 95 are probably the same. All of the stars in Fig. 1 are entitled from their magnitude to a place in the D. M. It is evident that there has been a great change in the relation of these stars since the meridian observations of Argelander, or that there are very considerable errors in the D. M. places of two or more of them. I have found it necessary in the past twenty-five years to compare the D. M. catalogues with the sky in the identification of small stars many hundreds of times, and I do not recall at this time any instance of serious error or omission. I have, therefore, a high degree of confidence in the substantial accuracy of this great work. Unfortunately the new catalogues of the *Astronomischen Gesellschaft* are very defective with respect to the D. M. stars in the lower magnitudes. Of the first hundred stars given in the D. M. zone of 62°, less than one-third are found in the new catalogue covering this region, and all the stars in question are missing. So far as I know there are no meridian observations of them other than those in Argelander, and hence there is no data for de-

termining their previous relations to each other, and their proper motions. For this reason I have connected them together by the measures given above, so that hereafter the moving star or stars can be easily identified. It is certain that one of the components of the pair is moving, and there can be but little doubt of this being rectilinear motion, but that does not appear to be sufficient to entirely explain the difference between the two diagrams.

RECENT ADVANCES IN SCIENCE.*

WILLIAM CROOKS.

It has long been to me a haunting problem how to reconcile this apparently boundless outpour of energy with accepted canons. But, as Dr. Johnstone Stoney reminds me, the resources of molecular movements are far from exhausted. There are many stores of energy in nature that may be drawn on by properly constituted bodies without very obvious cause. Some time since I drew attention to the enormous amount of locked-up energy in the ether; nearer our experimental grasp are the motions of the atoms and molecules, and it is not difficult mentally so to modify Maxwell's demons as to reduce them to the level of an inflexible law and thus bring them within the ken of a philosopher in search of a new tool. It is possible to conceive a target capable of mechanically sifting from the molecules of the surrounding air the quick from the slow movers. This sifting of the swift moving molecules is effected in liquids whenever they evaporate, and in the case of the constituents of the atmosphere, wherever it contains constituents light enough to drift away molecule by molecule. In my mind's eye I see such a target as a piece of metal cooler than the surrounding air acquiring the energy that gradually raises its temperature from the outstanding effect of all its encounters with the molecules of the air about it; I see another target of such a structure that it throws off the slow moving molecules with little exchange of energy, but is so influenced by the quick moving missiles that it appropriates to itself some of their energy. Let uranium or polonium, bodies of densest atoms, have a structure that enables them to throw off the slow moving molecules of the atmosphere, while the quick moving molecules, smashing on to the surface, have their energy reduced and that of the target correspondingly in-

* Continued from page 501, Vol. VI.

creased. The energy thus gained seems to be employed partly in dissociating some of the molecules of the gas (or in inducing some other condition which has the effect of rendering the neighboring air in some degree a conductor of electricity) and partly in originating an undulation through the ether, which, as it takes its rise in phenomena so disconnected as the impacts of the molecules of the air, must furnish a large contingent of light waves of short wave-length. The shortness in the case of these Becquerel rays appears to approach without attaining the extreme shortness of ordinary Röntgen rays. The reduction of the speed of the quick moving molecules would cool the layer of air to which they belong, but this cooling would rapidly be compensated by radiation and conduction from the surrounding atmosphere; under ordinary circumstances the difference of temperature would scarcely be perceptible, and the uranium would thus appear to perpetually emit rays of energy with no apparent means of restoration.

The total energy of both the translational and internal motions of the molecules locked up in quiescent air at ordinary pressure and temperature is about 140,000 foot-pounds in each cubic yard of air. Accordingly the quiet air within a room 12 feet high, 18 feet wide and 22 feet long contains energy enough to propel a one-horse engine for more than twelve hours. The store drawn upon naturally by uranium and other heavy atoms only awaits the touch of the magic wand of Science to enable the twentieth century to cast into the shade the marvels of the nineteenth.

Whilst placing before you the labors and achievements of my comrades in science I seize this chance of telling you of engrossing work of my own on the fractionation of yttria to which for the last eighteen years I have given ceaseless attention. In 1883, under the title of 'Radiant Matter Spectroscopy,' I described a new series of spectra produced by passing the phosphorescent glow of yttria, under molecular bombardment *in vacuo*, through a train of prisms. The visible spectra in time gave up their secrets, and were duly embalmed in the *Philosophical Transactions*. At the Birmingham meeting of the British Association in 1886 I brought the subject before the Chemical Section, of which I had the honor to be President. The results led to many speculations on the probable origin of all the elementary bodies—speculations that for the moment I must waive in favor of experimental facts.

There still remained for spectroscopic examination a long tempting stretch of unknown ultra-violet light, of which the ex-

ploration gave me no rest. But I will not now enter into details of the quest of unknown lines. Large quartz prisms, lenses and condensers, specially sensitized photographic films capable of dealing with the necessary small amount of radiation given by feebly phosphorescing substances,* and, above all, tireless patience in collating and interpreting results, have all played their part. Although the research is incomplete, I am able to announce that among the groups of rare earths giving phosphorescent spectra in the visible region there are others giving well-defined groups of bands which can only be recorded photographically. I have detected and mapped no less than six such groups extending to λ 3060.

Without enlarging on difficulties, I will give a brief outline of the investigation. Starting with a large quantity of a group of the rare earths in a state of considerable purity, a particular method of fractionation is applied, splitting the earths into a series of fractions differing but slightly from each other. Each of these fractions, phosphorescing *in vacuo*, is arranged in the spectrograph, and a record of its spectrum photographed upon a specially prepared sensitive film.

In this way, with different groups of rare earths, the several invisible bands were recorded—some moderately strong, others exceedingly faint. Selecting a portion giving a definite set of bands, new methods of fractionation were applied, constantly photographing and measuring the spectrum of each fraction. Sometimes many weeks of hard experiment failed to produce any separation, and then a new method of splitting up was devised and applied. By unremitting work—the solvent of most difficulties—eventually it was possible to split up the series of bands into various groups. Then, taking a group which seemed to offer possibilities of reasonably quick result, one method after another of chemical attack was adopted, with the ultimate result of freeing the group from its accompanying fellows and increasing its intensity and detail.

As I have said, my researches are far from complete, but about one of the bodies I may speak definitely. High up in the ultra-violet, like a faint nebula in the distant heavens, a group of lines was detected, at first feeble and only remarkable on account of their isolation. On further purification these lines grew stronger.

* In this connection I am glad to acknowlege my indebtedness to Dr. Schumann, of Leipzig, for valuable suggestions and detail of his own apparatus, by means of which he has produced some unique records of metallic and gaseous spectra of lines of short wave-length.

Their great refrangibility cut them off from other groups. Special processes were employed to isolate the Earth, and using these lines as a test, and appealing at every step to the spectrograph, it was pleasant to see how each week the group stood out stronger and stronger, while the other lines of yttrium, samarium, ytterbium, etc., became fainter, and, at last, practically vanishing, left the sought-for group strong and solitary. Finally, within the last few weeks, hopefulness has emerged into certainty, and I have absolute evidence that another member of the rare earth groups has been added to the list. Simultaneously with the chemical and spectrographic attack, atomic-weight determinations were constantly performed.

As the group of lines which betrayed its existence stand alone, almost at the extreme end of the ultra-violet spectrum, I propose to name the newest of the elements Monium, from the Greek *μόνος*, alone. Although caught by the searching rays of the spectrum, monium offers a direct contrast to the recently discovered gaseous elements, by having a strongly-marked individuality; but, although so young and willful, it is willing to enter into any number of chemical alliances.

Until my material is in a greater state of purity I hesitate to commit myself to figures, but I may say that the wave-lengths of the principal lines are 3120 and 3117. Other fainter lines are at 3219, 3064 and 3060. The atomic weight of the element, based on the assumption of R_2O_3, is not far from 118—greater than that accepted for yttrium and less than that for lanthanum.

I ought almost to apologize for adding to the already too long list of elements of the rare earth class—the asteroids of the terrestrial family. But as the host of celestial asteroids, unimportant individually, become of high interest when once the idea is grasped that they may be incompletely coagulated remains of the original nebula, so do these elusive and insignificant rare elements rise to supreme importance when we regard them in the light of component parts of a dominant element, frozen in embryo, and arrested in the act of coalescing from the original protyle into one of the ordinary and law-abiding family for whom Newlands and Mendeleeff have prepared pigeon-holes. The new element has another claim to notice. Not only is it new in itself, but to discover it a new tool had to be forged for spectroscopic research.

Further details I will reserve for that tribunal before whom every aspirant for a place in the elemental hierarchy has to substantiate his claim.

These, then, are some of the subjects, weighty and far-reaching,

on which my own attention has been chiefly concentrated. Upon one other interest I have not yet touched—to me the weightiest and the farthest reaching of all.

No incident in my scientific career is more widely known than the part I took many years ago in certain psychic researches. Thirty years have passed since I published an account of experiments tending to show that outside our scientific knowledge there exists a Force exercised by intelligence differing from the ordinary intelligence common to mortals. This fact in my life is, of course, well understood by those who honored me with the invitation to become your President. Perhaps among my audience some may feel curious as to whether I shall speak out or be silent. I elect to speak, although briefly. To enter at length on a still debatable subject would be unduly to insist on a topic which—as Wallace, Lodge and Barrett have already shown—though not unfitted for discussion at these meetings, does not yet enlist the interest of the majority of my scientific brethren. To ignore the subject would be an act of cowardice—an act of cowardice I feel no temptation to commit.

To stop short in any research that bids fair to widen the gates of knowledge, to recoil from fear of difficulty or adverse criticism, is to bring reproach on science. There is nothing for the investigator to do but to go straight on; 'to explore up and down, inch by inch, with the taper his reason;' to follow the light wherever it may lead, even should it at times resemble a will-o'-the wisp. I have nothing to retract. I adhere to my already published statements. Indeed, I might add much thereto. I regret only a certain crudity in those early expositions which, no doubt justly, militated against their acceptance by the scientific world. My own knowledge at that time scarcely extended beyond the fact that certain phenomena new to science had assuredly occurred, and were attested by my own sober senses and, better still, by automatic record. I was like some two-dimensional being who might stand at the singular point of a Riemann's surface, and thus find himself in infinitesimal and inexplicable contact with a plane of existence not his own.

I think I see a little farther now. I have glimpses of something like coherence among the strange elusive phenomena; of something like continuity between those unexplained forces and laws already known. This advance is largely due to the labors of another association of which I have also this year the honor to be President—the Society for Psychical Research. And were I now introducing for the first time these inquiries to the world of sci-

ence I should choose a starting-point different from that of old. It would be well to begin with *telepathy*; with the fundamental law, as I believe it to be, that thoughts and images may be transferred from one mind to another without the agency of the recognized organs of sense—that knowledge may enter the human mind without being communicated in any hitherto known or recognized ways.

Although the inquiry has elicited important facts with reference to the mind, it has not yet reached the scientific stage of certainty which would entitle it to be usefully brought before one of our Sections. I will, therefore, confine myself to pointing out the direction in which scientific investigation can legitimately advance. If telepathy take place we have two physical facts—the physical change in the brain of *A*, the suggester, and the analogous physical change in the brain of *B*, the recipient of the suggestion. Between these two physical events there must exist a train of physical causes. Whenever the connecting sequence of intermediate causes begins to be revealed, the inquiry will then come within the range of one of the Sections of the British Association. Such a sequence can only occur through an intervening medium. All the phenomena of the universe are presumably in some way continuous, and it is unscientific to call in the aid of mysterious agencies when, with every fresh advance in knowledge, it is shown that ether vibrations have powers and attributes abundantly equal to any demand—even to the transmission of thought. It is supposed by some physiologists that the essential cells of nerves do not actually touch, but are separated by a narrow gap which widens in sleep, while it narrows almost to extinction during mental activity. This condition is so singularly like that of a Branly or Lodge coherer as to suggest a further analogy. The structure of brain and nerve being similar, it is conceivable there may be present masses of such nerve coherers in the brain whose special function it may be to receive impulses brought from without through the connecting sequence of ether waves of appropriate order of magnitude. Röntgen has familiarized us with an order of vibrations of extreme minuteness compared with the smallest waves with which we have hitherto been acquainted, and of dimensions comparable with the distances between the centers of the atoms of which the material universe is built up; and there is no reason to suppose that we have here reached the limit of frequency. It is known that the action of thought is accompanied by certain molecular movements in the brain, and here we have physical vibrations capable,

from their extreme minuteness, of acting direct on individual molecules, while their rapidity approaches that of the internal and external movements of the atoms themselves.

Confirmation of telepathic phenomena is afforded by many converging experiments and by many spontaneous occurrences only thus intelligible. The most varied proof, perhaps, is drawn from analysis of the sub-conscious workings of the mind, when these, whether by accident or design, are brought into conscious survey. Evidence of a region below the threshold of consciousness has been presented, since its first inception, in the *Proceedings of the Society for Physical Research*; and its various aspects are being interpreted and welded into a comprehensive whole by the pertinacious genius of F. W. H. Myers. Concurrently, our knowledge of the facts in this obscure region has received valuable additions at the hands of laborers in other countries. To mention a few names out of many, the observations of Richet, Pierre Janet and Binet (in France), of Breuer and Freud (in Austria), of William James (in America), have strikingly illustrated the extent to which patient experimentation can probe subliminal processes, and can thus learn the lessons of alternating personalities and abnormal states. Whilst it is clear that our knowledge of subconscious mentation is still to be developed, we must beware of rashly assuming that all variations from the normal waking condition are necessarily morbid. The human race has reached no fixed or changeless ideal; in every direction there is evolution as well as disintegration. It would be hard to find instances of more rapid progress, moral and physical, than in certain important cases of cure by suggestion—again to cite a few names out of many—by Liébault, Bernheim, the late Auguste Voisin, Bérillon (in France), Schrenck Notzing (in Germany), Forel (in Switzerland), van Eeden (in Holland), Wetterstrand (in Sweden), Milne-Bramwell and Lloyd Tuckey (in England). This is not the place of details, but the *vis medicatrix* thus evoked, as it were, from the depths of the organism, is of good omen for the upward evolution of mankind.

A formidable range of phenomena must be scientifically sifted before we effectually grasp a faculty so strange, so bewildering, and for ages so inscrutable, as the direct action of mind on mind. This delicate task needs a rigorous employment of the method of exclusion—a constant setting aside of irrelevant phenomena that could be explained by known causes, including those far too familiar causes, conscious and unconscious fraud. The inquiry

unites the difficulties inherent in all experimentation connected with mind, with tangled human temperaments and with observations dependent less on automatic record than on personal testimony. But difficulties are things to be overcome even in the elusory branch of research known as Experimental Psychology. It has been characteristic of the leaders among the group of inquirers constituting the Society for Physical Research to combine critical and negative work with work leading to positive discovery. To the penetration and scrupulous fair-mindedness of Professor Henry Sidgwick and of the late Edmund Gurney is largely due the establishment of canons of evidence in physical research, which strengthen while they narrow the path of subsequent explorers. To the detective genius of Dr. Richard Hodgson we owe a convincing demonstration of the narrow limits of human continuous observation.

It has been said that 'Nothing worth the proving can be proved, nor yet disproved.' True though this may have been in the past, it is true no longer. The science of our century has forged weapons of observation and analysis by which the veriest tyro may profit. Science has trained and fashioned the average mind into habits of exactitude and disciplined perception, and in so doing has fortified itself for tasks higher, wider, and incomparably more wonderful than even the wisest among our ancestors imagined. Like the souls in Plato's myth that follow the chariot of Zeus, it has ascended to a point of vision far above the earth. It is henceforth open to science to transcend all we now think we know of matter, and to gain new glimpses of a profounder scheme of Cosmic Law.

An eminent predecessor in his chair declared that "by an intellectual necessity he crossed the boundary of experimental evidence, and discerned in that matter, which we in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the potency and promise of all terrestial life." I should prefer to reverse the apothegm, and to say that in life I see the promise and potency of all forms of matter.

In old Egyptian days a well-known inscription was carved over the portal of the temple of Isis: "I am whatever hath been, is, or ever will be; and my veil no man hath yet lifted." Not thus do modern seekers after truth confront nature—the word that stands for the baffling mysteries of the universe. Steadily, unflinchingly; we strive to pierce the inmost heart of Nature, from what she is to reconstruct what she has been, and to

prophesy what she yet shall be. Veil after veil we have lifted, and her face grows more beautiful, august and wonderful, with every barrier that is withdrawn.

AN ILLUSION AND ITS CAUSE.

R. M. McCREARY.

FOR POPULAR ASTRONOMY.

On the top of a hill that forms my western horizon line stands a number of buildings. One evening recently I watched the Sun setting beyond the buildings and saw something which, if I had not often witnessed similar appearances, I would have regarded as a wonderful phenomenon. The Sun looked larger than the buildings; it passed directly behind one which I know is 50 feet long and I saw the whole building projected on its disk and there was disk room for more, so that the Sun on that occasion appeared to be more than 50 feet in diameter.

Why was this? What caused the illusion? For it was an illusion, as a little experiment described in Sec. 88 of Young's General Astronomy will demonstrate. Or, to make the question general, why does the Sun, and the Moon, too, appear larger when near the horizon than when at a high altitude? The question is suggested whenever one sees the Sun or the Moon rise or set; it has often been asked but there is recent and, I suppose, good authority for saying that it has never been satisfactorily answered. Where many have failed it may be presumption for me to attempt but I will attempt; if I succeed a long felt want will be supplied; if I fail I shall get myself into good company, into the company of some who have been eminent for astronomical attainments but who have tried and failed to account for the illusion.

I will begin by supposing a case. Suppose a lady goes shopping and buys a piece of goods; she returns home and measures her purchase with what once was a yard stick but from which, unknown to her, a piece has been cut. She will think that she has more goods than she purchased. Suppose, further, that the lady cannot see or cannot be convinced that her supposed yard stick is not a yard long. In that case she will go down to her grave firm in the opinion that she had got the big end of at least one bargain. Now something analogous to this happens whenever we see the Sun or Moon apparently enlarged. When we see those bodies high in the sky we apply to them angular measurement

and thus see them as of their true angular diameters. We are then in the same state of mind as was the lady when she left the store with her purchase. But when we see the Sun or Moon near the horizon we apply to them linear measurement, the dimensions in feet, yards, or other units, which we know or can always very closely estimate, of houses, trees, fences or other terrestrial objects near which they appear, but we do not take account of the shrinkage which, owing to distance, our measuring instruments have undergone. In consequence the Sun or Moon, in the position supposed, appears to be enlarged just in the ratio that the distance reduced size bears to the real size of our comparison objects. We are deceived just as the woman was deceived when she measured her stuff with a yard stick that was not a yard stick. And we will continue to be deceived. As the woman in the little fable I have constructed pins her faith to her supposed yard stick and lives and will die under a hallucination, so we, as long as the Sun and Moon shall rise and set for us, will apply to their measurement our distance diminished terrestrial standards and in consequence we will continue to see those bodies apparently enlarged according to the distance that intervenes between us and our standards of measurement.

It cannot, in the nature of things, be otherwise. We carry in our minds definite ideas of linear extension, of the length of a foot, a yard, a rod and, within reasonable limits, of their multiples, and when we know or estimate that a terrestrial object corresponds in extent with any number of these units we see it, and we cannot help seeing it, whether it is nearer or more remote, as of that size. We see it in its true or estimated linear dimensions notwithstanding, or in spite of, the fact that we know that its angular size is reduced by distance. A man 6 feet high seen at a distance of ¼ mile really measures about an inch but we see him as a man; a panel of fence a mile away measures about ¾ of an inch but we see it as a rod, and the house, behind which I saw the Sun setting, seen from my window, actually measures but little more than ½ inch but I see it as a 50-foot building. I saw it so on the occasion noted, I used it for measuring the Sun and as my standard of measurement appeared magnified nearly a hundred fold the Sun seemed enlarged in exactly the same ratio.

I did not set out to explain why we see terrestrial objects in their true proportions regardless of distance. It is the result, I suppose, of experience. But the explanation is not necessary; the fact that we see objects so and employ them as thus seen, instead of as they ought to appear, for measuring the disks of the Sun

and Moon is, I believe, the cause of the illusion which it was my purpose to explain.

The illusion for which the foregoing is an attempt to account must not be confounded with a similar illusion arising from a different cause; that is, the moderate, gradual change in the apparent sizes of the lunar and solar disks which they undergo as they recede from the eastern or approach the western horizon. The latter illusion is owing, as was long ago explained by Alhazen, to the apparent ellipticity of the sky in consequence of which we see the Sun and Moon projected on a background that is nearer or more distant according as those bodies are viewed at a higher or lower altitude. We view, not the Sun or the Moon directly, but its projection on the sky, and the illusion appears; if we view them directly, through smoked or colored glass, the background cannot be seen and the illusion vanishes.

GREENSBURG, Pa.

PLUS PROBANS QUAM NECESSE EST.

ASAPH HALL.

FOR POPULAR ASTRONOMY.

Professor Swift is naturally indignant at the supposed charge of cooking an observation, but his long and useful career in astronomy will surely protect him from charges of this kind. Still we all make mistakes, and Professor Swift's statements bring to mind a common habit of proving too much; a fault for which I have adopted the phrase above, *plus probans quam necesse est*. Thus why should Professor Swift, thirty-six years after the event, provide his comet with a tail, even of "gegenschein faintness," when no one else saw it. Is it not a case of proving too much? It will be remembered that twenty years ago Professors Swift and Watson claimed they had discovered in Colorado two Vulcans, during a total eclipse of the Sun. I met Professor Watson at Manitou a few days after the eclipse and he told me he thought that he had found a Vulcan, but he said nothing about two planets, and did not appear to be very certain of any. I was surprised, therefore, on my return to Washington to find that Watson claimed to have discovered two Vulcans. I immediately wrote to him calling his attention to what I thought weakened his argument. He replied in an angry letter, with nearly the statements of Professor Swift about negative testi-

mony. Professor Watson published his observations in detail in Silliman's Journal of Science. As soon as this was done Dr. Peters showed that if we suppose a small and quite probable error in the zero of Watson's reading circle the positions of his two assumed planets were thrown on two well known fixed stars. Although this is negative testimony, the probability of such a coincidence is so small that the twin Vulcans disappeared from rational astronomy. I think they are not mentioned now even by the astronomical writers of the *Atlantic Monthly*.

Again take the explanation which Professor Simon Newcomb offers for the variations of latitude, and also Dr. Joseph Morrison's explanation of the Dial of Ahaz. Are not both these explanations subject to the error of proving too much? When we see profound mathematicians making this mistake we may certainly look for it in other men.

CAMBRIDGE, MASS.
1898, Dec. 14.

DARK SPOTS IN THE N. TROPICAL REGION OF JUPITER.

W. F. DENNING.

FOR POPULAR ASTRONOMY.

During the last opposition of Jupiter there were a number of dark elongated spots lying just exterior to the N. equatorial belt and projected on a very delicate narrow belt. Two of these spots were very conspicuous and a third moderately so on a good night. Several others were glimpsed at various times during the opposition. I watched three of these spots for the purpose of ascertaining their rates of rotation and found it as follows:

		Period		
		h	m	s
Spot *A*.	249 rotations	9	55	27.7
" *B*.	220 "	9	55	26.3
" *C*.	302 "	9	55	24.8

These markings were therefore not moving at perfectly consistent rates for *A* and *B* exhibited a difference of 3 seconds on their respective rotation periods.

This region of Jupiter's visible surface appears to have increased its motion during the last few years, for in 1894-5 I found the rate $9^h\ 55^m\ 35^s$ and in 1895-6 it was $9^h\ 55^m\ 33.2^s$. It will be interesting to watch the markings in about Lat. $+15°$ in future years to trace out these varying motions and to discover

whether they are periodically recurrent. Numerous observations have already been made of spots situated between Lat. + 5° and + 15° and I have compiled the following list of rotation periods derived by different observers from them:

Year.	Observer.	Period. h	m	s	Notes.
1672	I. D. Cassini	9	55	40	Break in IV equa. belt.
1788	I. H. Schroeter	9	55	33.6	White spot on N. side equa. belt.
1835	G. B. Airy	9	55	21 3	Spot on N. equa. belt.
1835	I. H. Mädler	9	55	26 5	2 spots on N. equa. belt.
1881	O. Lohse	9	55	35.2	166 rotations.
1885-6	W. F. Denning	9	55	31.6	Bright spot.
1887	F. Terby	9	55	34.5	Mean of 2 spots.
1887	A. S. Williams	9	55	36 8	Mean of 17 spots.
1888	A. S. Williams	9	55	40 9	Mean of 18 spots.
1890	G. W. Hough	9	55	34.3	Mean of 5 spots.
1890-1	W. F. Denning	9	55	38.3	Bright spot.
1890-1	E. E. Barnard	9	55	30.3	Mean of 2 dark spots.
1891	G. W. Hough	9	55	27.4	"
1894-5	W. F. Denning	9	55	35.0	Mean of 9 spots.
1894-5	G. W. Hough	9	55	31.7	Mean of 4 white spots.
"	" "	9	55	35.1	" 6 dark spots.
1895-6	I. Gledhill	9	55	33	" 2 dark spots.
"	G. W. Hough	9	55	34 5	" " "
"	W. F. Denning	9	55	33.2	" " "
"	A. A. Rambaut	9	55	33.6	1 dark spot.
1898	W. F. Denning	9	55	26 3	Mean of 3 dark spots.
"	T. E. R. Phillips	9	55	25.8	" " "

This particular latitude is evidently the seat of active disturbance for at nearly every opposition it appears to present us with new objects and a different rate of velocity.

BRISTOL, ENGLAND.

1898, November 21.

WHO DISCOVERED THE COMET OF THE PERSIEDS (1862 III)?

FOR POPULAR ASTRONOMY.

SIR:—The correspondence in recent numbers of your journal with reference to the above question has interested me greatly. My opinion as a perfectly disinterested outsider, is that you did quite right in calling the object "Tuttle's Comet." I have myself in various lists of modern comets which I compiled for different publications ascribed the discovery of 1862 III to Swift, but I went solely on the authority of Chambers and the real facts of the case were unknown to me.

Different people will no doubt vary in their opinions as to whom really belongs the credit of their important discovery but I take the matter in this way.

Swift saw the comet first, but he did not know it was new and

therefore the mere fact of his seeing it constituted no discovery at all! He says he entertained no suspicion that the object was an entirely new comet until it was announced as such by Tuttle. I believe that in such a case priority of announcement should invariably be held synomymous with priority of discovery. To discover an object a man must not only see a thing but recognize that it is new by proper tests and references and announce it to the world. If Swift's claim were admitted then Flamsteed, Bradley, Mayer and LeMonnier "discovered" Uranus many years before William Herschel. Flamsteed in point of fact, saw the planet in 1690 and '91, years before Herschel in 1781, not only detected it but realized its unusual character and called the attention of astronomers to it.

Arguing on the same lines LeLande discovered Neptune half a century before the researches of LeVerrier and Adams enabled Challis to pick it up in the Northumberland telescope at Cambridge.

To be fully regarded as a discoverer we have therefore to do some[illegible]ng more than merely see an object. In 1885 Hartwig announced that on Aug. 31 he had seen a new star or stellar nucleus in the great nebula of Andromeda and a short time after several observers asserted they had seen the star one or two weeks previously. Their testimony may be perfectly reliable but to my mind Hartwig deserves the title of sole discoverer since he saw the object, comprehended the nature and importance of his discovery and called public attention to it. The observer who sees anything novel and fails to investigate it sufficiently to realize what he is looking at deserves to lose (like LeMonnier for instance, whose carelessness lost him Uranus) all claim to credit in connection with the actual discovery. In fact he rather deserves censure for the neglect which makes him unable to grasp the prize which has fortunately first come in his way.

In regard to Comet 1862 III the mistake of Swift was natural enough under the circumstances and many of us would have made it. But it was unfortunate since to my mind it gave the comet to Tuttle. Still, Professor Swift has gained so many honors in searching for new comets and nebulæ that it will make little difference whether or not the comet of July 1862 is deducted from his claims. This comet is however intensely interesting from the fact that its orbit appears to be identical with that of the celebrated meteor shower of August. Yours Sincerely,

BRISTOL, ENGLAND. W. F. DENNING.
1898, November 21.

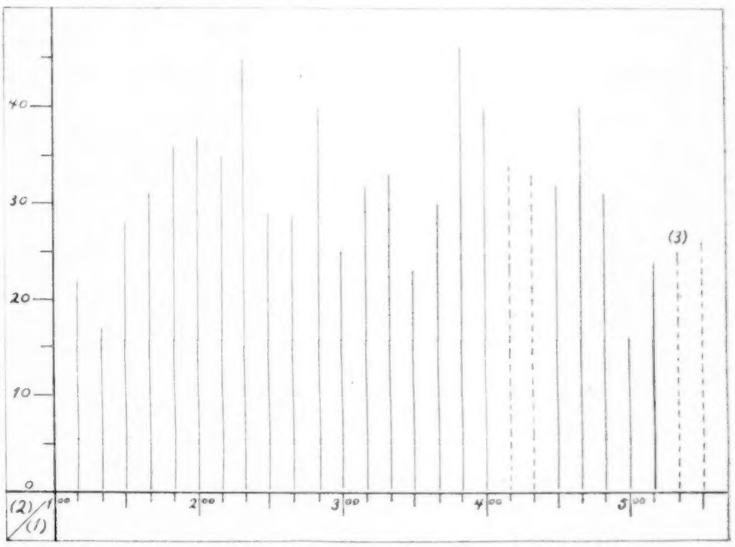
OBSERVATIONS OF THE LEONIDS AT THE STATE UNIVERSITY OF IOWA.

COMMUNICATED BY PROFESSOR L. G. WELD.

FOR POPULAR ASTRONOMY.

On account of continued cloudy weather it was possible to observe the Leonids from this station only during the early morning hours of Monday, Nov. 14. The following observations were made by Mr. Burton S. Easton, instructor in Astronomy, assisted by eight students.

The sky was divided into definite regions and a careful watch kept upon each, the purpose being to make as accurate a count of the meteors as possible and to note all extraordinary forms. The observers were required to announce instantly the appearance of each meteor, thus avoiding any significant duplication in the count. The total number of meteors observed was 913. It cannot be said that the display was remarkable for its brilliancy. The result of the count is exhibited in the accompanying graph. It will be observed that there were two well defined maxima. Apparently a third maximum was approaching but on-coming daylight prevented further observation.



(1) *Central time.*
(2) *Number of meteors counted during the period of ten minutes ending at the time indicated.*
(3) *Daybreak.*

The distribution of the observed "flights" is shown roughly by the following table, from which the above graph was constructed. The changes in the partition of the sky were incident to changes in the personnel of the observing party.

Central Time.	N. E.	E.	S. E.	S.	S. W.	N. W.	Zenith.	Totals.
12:20 — 1:00								40
1:00 — 1:10	1	6		6	4	5		22
1:10 — 1:20	2	4		2	4	5		17
1:20 — 1:30	1	6		5	8	8		28
1:30 — 1:40	12	6		5	7	1		31
1:40 — 1:50	7	10		2	10	7		36
1:50 — 2:00	6	10		9	3	9		37
2:00 — 2:10	6	8		1	7	13		35
2:10 — 2:20	6	13		5	6	9	6	45
2:20 — 2:30	9	6		2	4	7	1	29
2:30 — 2:40	2	7		6	6	5	3	29
2:40 — 2:50	8	7		9	8	7	1	40
2:50 — 3:00	6	4		5	3	6	1	25
3:00 — 3:10	10		11		5	6	0	32
3:10 — 3:20	6		11		10	6	0	33
3:20 — 3:30	11		6		2	3	1	23
3:30 — 3:40	8		9		4	7	2	30
3:40 — 3:50	13		7		11	11	4	46
3:50 — 4:00	10		9		7	10	4	40
4:00 — 4:20	30		9		10	18		67
4:20 — 4:30	13		6		6	7		32
4:30 — 4:40	6		19		6	9		40
4:40 — 4:50	6		11		4	10		31
4:50 — 5:00	3		0		3	10		16
5:00 — 5:10	4		7		5	8		24
5:10 — 5:30	10		10		20	10		50
5:30 — 5:40	5		11		3	6		25
5:40 — 5:45					6	4		10
Total Number Observed								913

The following meteors were observed as exceptional in respect to the characters noted. Owing to the fact that only one or two members of the party had any knowledge whatever of Uranography the positions given are merely rough approximation. Unless otherwise stated the general direction was from the radiant and the color white. The times may be in error in some instances as much as a minute.

Central Time. NOTES.

1:05. Brilliant white. Through Cetus.

1:07. Brilliant white. Above the Dipper.

1:15. White and very swift. Through Orion.

1:18. Brilliant white and with a fine trail. Through the "square" of Pegasus.

1:19. Brilliant white. High in east.

1:21. White trail changing to red nucleus at end of path. (Atmosphere?) Sirius through Columba.

1:22. Brilliant white and with a fine trail. Past north pole into Draco.

1:23. A long path from Zenith to S. W. W. point.

1:24. Bright white with a short curved path. In eastern horizon.

1:26. Brilliant white. In west from Cepheus toward S. point. A Leonid?

1:28. A red nucleus. Down prime vertical from about 80° altitude, in the west.

1:30. A short curve over Mars.

1:36. A fine white trail with some permanance (1^s +). From Sirius into Pegasus.

1:43. A reddish curve over Cor Caroli.

1:45. A red meteor. From Aldebaran toward west point.

1:45. A meteor bursting. (No report heard but considerable other noise was going on). A little south of western prime vertical and perhaps 50° high.

1:46. Small. From γ Andromedae toward west A Leonid?

1:47. A red meteor. From Aldebaran toward west point.

1:48. Bright and reddish. From Mars toward west point.

1:49. A fine brilliant white trail with a permanence of about 3^s. Due west from bowl of the Dipper.

1:53. A good trail. (1^s). From $\varkappa$ Ursæ Majoris.

1:59. A brilliant white *flash*, from Pleiades to W. of N.

2:07. A fine white trail. To the west below Ursa Major.

2:14. A yellow meteor. Directly from Leo, but direction not recorded.

2:19. A small meteor below Procyon. Probably not a Leonid.

2:25. Brilliant white, above and to west of pole.

2:31. A white curve above Cor Caroli.

2:33. A fine white trail with permanence of about 2^s. Down western prime vertical.

2:38 A small meteor starting near south point and crossing Caput Hydræ. Not a Leonid.

2:40. A curve from Lepus.

2:45. A curve from Gemini *into* Leo. Not a Leonid.

2:48. A small, not bright, red meteor. From zenith toward southeast. Not a Leonid.

2:50. A fine brilliant white trail, with permanence of about 3^s. Under bowl of Dipper.

2:58. A white trail from Orion into the southwest.

2:59 A red meteor with a good red trail. Into the southeast from toward radiant (?).

3:07. Brilliant white. From ξ Draconis vertically downward.

3:13. Brilliant white. Under Ursa Minor toward west.

3:57. A faint curve toward γ Andromedæ.

4:18. A fine white trail with permanance of about 2^s. Through Ursa Minor.

4:18. A meteor with a very peculiar path consisting of a horizontal motion toward the south, compounded with a slight vertical motion, producing a distinct wave. The student observing it was very positive about this. It has been suggested that this was a "screw" seen from the side. Its altitude, rather accurately determined by means of a tall steeple, was 10° —, the length of the path

uncertain (15°?). This would bring its motion as through Boötes, from below Arcturus.

4:24. A white, not very brilliant meteor with an apparently hesitating ("jerky") path. Possibly caused by rapid variations in brightness, possibly by actual variations in motion, possibly a simple deception. Vertically downward in southwest.

4:28. Brilliant white. In northeast.

4:30. Three bright white meteors with trails in rapid succession. In southeast.

4:38. A short meteor reported to have suddenly changed direction. In southeast but further details not reported. (Doubtful?)

5:14. A brilliant white meteor with a good trail. Through Draco.

5:15. A curve through Perseus.

5:25. A small meteor rising from the southwest. Not a Leonid.

5:32. Two fine white meteors with good trails in quick succession. Across Gemini.

IOWA CITY, IOWA,
Nov. 19, 1898.

THE NEW MINOR PLANET (433) 1898 DQ.

WM. W. PAYNE.

So much has been written, during the last four months, about this remarkable new asteroid, that it seems best to bring together the principal things that have been learned about it so far, that our readers may have a brief but connected view of the information thus gained. To make this most interesting story as real as possible we reproduce in this connection the simple figure which Dr. H. C. Wilson drew from the elements of the planetoid's orbit computed by Dr. Berberich from the three observations made by Witt, of Berlin, Aug. 14, 23 and 31.

This new planetoid was discovered by Herr Witt, of the Urania Observatory, of Berlin, on August 13. The discovery was communicated from the Astronomical Central station at Kiel, Germany, to Harvard College Observatory, the Central station for America, and by Mr. John Ritchie, there in charge to American astronomers on Sept. 5. It will be seen by these dates that a few days elapsed before the great importance of the discovery was realized. As soon as its rough orbit was known, astronomers everywhere were much interested in gaining the most definite knowledge attainable about this new and most singular little member of the solar family. It was at once seen that it would be difficult to photograph it, because its magnitude was rated as 11, and because its daily motion was 2000″. Such a faint body with so much motion would be likely to leave a very

faint trail on even sensitive plates, exposed in the best of atmospheric conditions. We will say more about this later on.

When the three observations noted above were known, the computers soon learned that the asteroid made its aphelion passage 1898, June, 20.443 Berlin time, that the longitude of its perihelion was 122° 17′ 14″, the inclination of its orbit to the ecliptic was 11° 6′ 57″; that the longitude of its ascending node was 303° 48′ 53″; that the eccentricity of its orbit was 0.22865; that its mean distance from the Sun was 1.4606, its least distance 1.1266 and its greatest distance was 1.7946, the Earth's distance from the Sun (93,000,000 miles) being unity; and its daily motion in arc was 2010″.131 and its period was 644.734, or one year, nine months and six days.

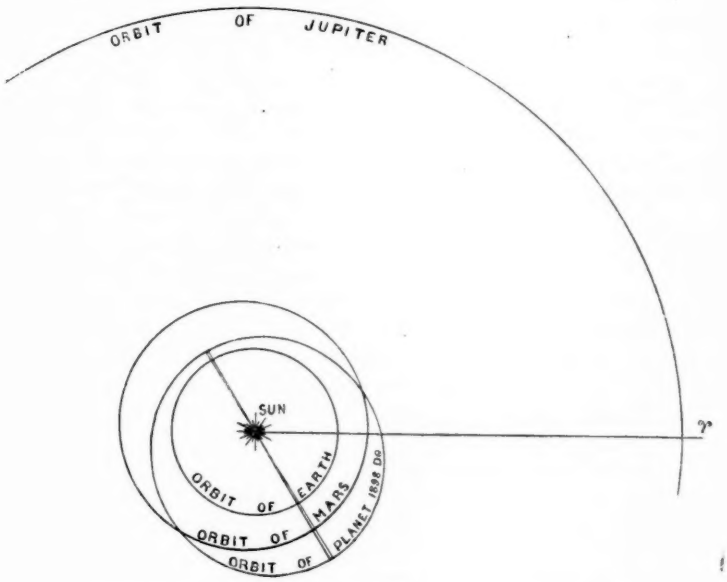


DIAGRAM SHOWING THE ORBIT OF THE NEW PLANET, 1898 DQ.

From these figures and the accompanying diagram it will be readily seen that the new planet passes the plane of the ecliptic, from north to south at 123° 48′ 53″, only about 1½° from the perihelion point. When the planet is nearest the Sun, it is also near the plane of the Earth's orbit, and thus comes as near to the Earth's path as possible considering the relative positions of

the two orbits in space. On account of this fact, the little planet may be only about 13,000,000 of miles away when nearest us, while the nearest approach of Mars, once in fifteen years, is about 35,000,000. It will also be noticed that at the time of discovery DQ was not far from the aphelion and Earth's position in her orbit was a little further eastward so that the two bodies from the early part of September slowly receded from each other. The new planet at time of discovery was of the eleventh magnitude, but when nearest the Earth its apparent size will rise to the sixth magnitude, and therefore be an interesting object for observation, not so much on account of its increased size as its nearness which will make it the best of celestial objects for the study of its parallax. The parallax of the Sun is 8″.80, that of Mars when nearest is about 23″ of arc, but the parallax of planet (433) will be 60″ of arc when nearest the Earth.

We then seek the times when this new planet will pass its perihelion point from year to year to learn when the Earth will come to a point opposite in her orbit that the above condition of near approach may be fulfilled. Since the perihelion of planet (433) is longitude 122° 17′, by referring to the Nautical Almanac we know the Earth passes the point in her orbit corresponding to that on January 22 of each year. Taking the aphelion date of the planet for this year as June 20, and reckoning backwards, it is easily found that 1894, the new planet passed its perihelion Jan. 21, and the next favorable date will occur on Jan. 3, 1917; but another more favorable will take place Jan. 25, 1924. The next time the Earth passes the new planet will be in November, 1900, and at the nearest approach of the two bodies will be 31,000,000 of miles apart.

This occasion will doubtless be utilized for observations for parallax, for it ought to give better results for this kind of work than Mars will give when in most favorable position. This is true for two reasons at least, the one on account of nearness, and the other because the new planet appears more like a stellar disk and will therefore give better opportunity for accurate measures than is possible on such a disk as the planet Mars presents when at near opposition. When the new planet is nearest the Earth at its own perihelion passage, astronomers ought to get the parallax of the Sun from two to three times as accurately as has been possible heretofore from any other source. The Sun's distance is now uncertain by about 50,000 miles. The parallax obtained by the observations of the new planet ought

to reduce this error certainly as much as one-half. The prospect of improving this important constant so easily and certainly is very encouraging.

Another astonishing feature about the orbit of the new planet is the fact that its mean distance from the Sun is 1.46 while that of the planet Mars is 1.52 nearly. Plainly enough is it true that more than one-half of the orbit of the new planet lies within the orbit of Mars, and on this account we wonder what can have been the history of this strange little body to have placed its path in such curious relations to that of Mars and the Earth.

In a very readable article in *Knowledge* for November, Mr. A. C. D. Crommelin brings out many interesting things, some of which have already been given, and others equally deserve attention. The simple relation of their periods of revolution around the Sun is expressed by dividing the new planet's period by that of the Earth; and the lower fraction that closely shows the relation of the two periods is $\frac{30}{17}$; that is, the Earth performs thirty revolutions around the Sun while DQ is making seventeen. As Mr. Crommelin says, it is easily seen that the Earth gains 13 revolutions on the new planet in 30 of our years, hence it gains one revolution in two years and one hundred and twelve days.

So if we know the time of any one opposition, any other one can be quickly found. Some surprising results also appear upon comparing the motions of Mars, Earth and the new planet in their respective orbits. It is evident from the relations of these orbits as viewed from the Sun that the planet Mars will sometimes be gaining on the new planet, in orbital motion, and sometimes the contrary will be true, this mainly depending on the fact that sometimes one has the inside track and sometimes the other. In these relations it is also now necessary to say that Mars and the new planet may each have inferior conjunction or be in opposition with respect to the other.

The same author referred to above, speaking of the relative motions of two of these planets, says:

"As viewed from the Earth, there is one feature in which DQ differs from all other superior planets; they are in all cases retrograding when in opposition, but DQ, when in perihelion has a velocity whose resolved part in the plane of the ecliptic is 18.95 miles per second, while that of the Earth is only 18.78 miles per second. The new planet is therefore gaining on the Earth instead of being left behind, and it will therefore be slowly advancing in longitude; it will have a rapid southward motion in latitude in consequence of its high inclination which will amount

to about 1⅓° per day. When in opposition near aphelion it will retrograde in longitude ½° per day, as was the case at its discovery; there will necessarily be an intermediate point where it will be exactly stationary in longitude, at the instant of opposition, and the Earth and planet will travel on side by side with the same velocity, maintaining for some days an almost constant distance."

In view of the near approach of the new planet to the Earth on the one hand, and also a near path to that of Mars on the other, it should be expected that perturbations would be the consequence in both cases. It has been suggested by some writers that from this cause the new planet may have been recently introduced into the solar system. It will be remembered by those who have in mind the discussions concerning the origin of the two satellites of Mars that the same view was advanced by some, soon after their discovery by Prof. Asaph Hall in 1877. This view of their origin did not meet with much favor mainly because of a lack of evidence to support such a theory. No one doubted but that such a thing might be possible although such an instance is unknown to celestial mechanics. How the proofs regarding the unique place of the orbit of this new planet may appear later, probably no one can now say. It is certain, however, that this interesting feature of our new and near neighbor's path will be diligently and exhaustively studied in all possible ways.

We have also been looking for some probable estimates of the mass of the new planet, but because it must be very small we have expected to find little of value, so soon after discovery. In circular No. 34, of Harvard College Observatory, Professor E. C. Pickering, when speaking of this planet, says: "Several interesting photometric problems present themselves in connection with this object. First, the approximate diameter may be determined by comparison with the brighter asteroids and satellites, assuming that the reflecting power is the same. Second, the great variation in distance of this object from the Earth will afford an excellent test of the law that light varies inversely as the square of the distance.

The existence of an absorbing medium in space will thus be tested. Thirdly, owing to the proximity of this object to the Earth at opposition, its phase angle will vary by a large amount. It will, therefore, afford an excellent test of the law connecting this angle with the variation in brightness, which has been found by two or three observers independently."

The results obtained by the photometer in determining the magnitude of the new planet on a mean date of Sept. 10, 1898, comes out as 11.30. It is therefore probable that the diameter of this planet will not vary much from 20 miles. When nearest it will appear in the telescope as a star near the sixth magnitude possibly a little less, and its disk will be too small for certain measurement even by the aid of the largest telescopes. It is true that our great telescopes will measure the distance between the two components of a double star less than ⅓″ of arc, which is about the diameter of the new planet when nearest, but the measurement of a faint planetary disk under high telescopic power is less favorable than in the case of a double star just supposed. From these circumstances, it is evident that Dr. S. C. Chandler had some ground for calling the new planet a stunted twin of Mars, and for suggesting to the discoverer the significant title of Pluto, as its most appropriate name. We have elsewhere, in this number, copied his letter to *The Observatory* (English) for November, 1898, which gives his views on this part of our theme.

We have before referred to the difficulty of photographing this minute planet on account of its faintness and its rapid motion. The two points which Professor E. C. Pickering makes in this particular, are, that short exposures will give only a very faint image, and that long exposures secure trails which can not be compared with the circular images of adjacent stars. From Sept. 6 to Sept. 21, 1898, ten attempts were made to ascertain the photographic brightness of the new planet with results varying from magnitude 12.65 to 12.78, giving an average of 12.75 ± 0.01. It thus appears from work so far, that the photographic magnitude of the new planet is more than one magnitude greater than the photometric. Professor Pickering thinks this is probably due to the color of the light of the planet, that it is more like the light of our Sun which is redder than that of the average star.

In regard to the perturbation of the new planet by the Earth, it may be noticed that

$2013''.7 \times 7 =$	$14094''.5$
$3548\ .2 \times 4 =$	$14192\ .8$
Difference	$98\ .3$

That is, seven times the planet's daily motion, is nearly four times that of the Earth's daily motion. This fact suggests a periodic long inequality something like that of Saturn and Jupiter. It is

also probable that Mars and the new planet will have relations equally interesting though, of course, less in magnitude. The effect of the small planet on the Earth, though small, will be something, and the article in our last issue by Gustave Ravené on the same subject is very suggestive in regard to its effect on the theoretical value of the acceleration of the Moon's mean motion. If the position is well taken, (and there seems to be no doubt of its theoretical accuracy) some interesting consequences will follow as pointed out in the article.

It is possible, as pointed out by a friend that the new planet may have been seen and charted at Bonn in the zone work carried on there for the last fifty years and more. In 1857, the new planet was near the Earth and so easily visible. Search in this direction might be of some advantage in getting early places of the planet.

If readers care to examine the elements of the orbit and ephemerides computed by various astronomers, recent numbers of this publication should be consulted. The latest elements we have seen appear in this number. They were computed by Professor W. J. Hussey, of Lick Observatory, and vary but little from those computed by Berberich and published in the October number of this journal, page 470, from which much of the data used has been drawn.

THE NAME OF PLANET DQ.

S. C. CHANDLER.

The unique character and singular orbital position of the little planet DQ, recently found by Mr. G. Witt, give the question of its nomenclature more interest than usually attaches to such matters. Of course the selection of a name, by courtesy and the precedent of custom, must be left to the taste and discretion of the discoverer. But it is trusted that he will pardon suggestion with regard to it, since this is a matter that other astronomers may take a legitimate interest in. It is manifest that this little object is destined to play a *rôle* in our astronomy of very great importance. It opens up, at a stroke, an unexpected and royal road to the problem of the solar parallax, as well as to those of nutation, the Moon's mass, and aberration. Melancholy as the statement may be it will reduce many of the existing discussions of these elements to the value of waste paper, records of futile

effort. Prominent as the object is thus likely to become it deserves a good name. I would suggest that of Pluto, and desire diffidently to urge the claims of this gentleman to the distinction. He is the only one of the six children of Saturn whom that unnatural father was unsuccessful in eating or otherwise destroying, who has not yet stood as godfather or godmother to some member of our planetary system. The other five, Jupiter, Neptune, Ceres, Vesta, and Juno have been worthily assigned, either to major planets, or to the earlier-discovered members of the Mars-Jupiter belt of asteroids. For the use of the later discoveries in this numerous group the list of available female deities has long since been exhausted, and now sweethearts, wives, girl-babies, and even provinces, cities, and town are jumbled together in our lists of these objects in a ludicrous way. Will it not now assist to a slight return to dignity and sanity of nomenclature to give some of the neglected male Gods a chance, and destroy the unfair monoply of the *beau sexe* in such matters? This seems a good time to begin. The body in question stands apart from the Mars Jupiter belt, practically a stunted twin of Mars himself. Moreover there is a certain fitness in the appellation arising from its faintness or invisibility on ordinary occasions. Pluto under his older name, Hades, was the "invisible" or "unknown," the God of Darkness. This invisibility he removes, with the helmet forged for his concealment by Vulcan, when he comes to opposition, shining then as a comparatively bright star, perhaps visible to the naked eye. This helmet, by the way, could serve as his conventional planetary symbol, if one is desired.

The addition of new asteroids to our lists has become such a nuisance that ordinarily the attachment of ridiculous names may be regarded as one of the helpful influences in discouraging further useless multiplication of these troublesome words of astronomy. But when one is born into the solar system which gives promise of paying for its keep, some attention should be devoted to a proper christening. In the solution of the problems I have indicated Pluto may be counted on to pay handsomely for his board and clothes.

It is hoped that the discoverer will take these considerations, and others which could be urged, into account in his selection of a name for this interesting and important little planet.—*The Observatory*.

16 Craigie Street, Cambridge Mass.,
1898, Nov. 2.

THE SOLAR CORONA.

ISAAC E. CHRISTIAN.

FOR POPULAR ASTRONOMY.

The most beautiful phenomenon connected with a total eclipse of the Sun, as well as the most perplexing one, is unquestionably the mysterious corona. This beautiful aureole of pearly light, with its flowing streamers and plume-like filaments reaching out millions of miles into the surrounding space never fails to impress the beholder with a profound sense of its incomparable beauty and transcendent grandeur.

To the student of solar physics, however, its nature and constitution, and the mysterious principles which underlie its existence, and the unknown forces by which it is controlled are far more interesting than its mere beauty and grandeur. The greatest efforts, therefore, are always made at every total eclipse of the Sun to make such observations as will lead to a better understanding of this apparently inexplicable phenomenon. On account of obvious difficulties, however, the number of observations which it has been possible to make is extremely limited and for the most part very unsatisfactory, and, as a consequence, our knowledge on the subject is very meagre and uncertain. The spectroscope, it is true, has demonstrated the existence of solid matter of some kind, presumably in a finely divided pulverulent condition in its outer parts and of an almost infinitely tenuous gaseous substance in its lower regions, but the nature of the mysterious forces by which this matter is enabled to assume and maintain the peculiar forms of flowing streamers and filaments, millions of miles in length, separated from each other by dark rift-like openings, has so far never received any satisfactory explanation. Indeed these vast streams of faintly luminous matter apparently fleeing from the Sun, in open defiance of his powerful attraction, seem to set at naught any explanation that it is possible to make.

But, after all, is it not at least possible that the structural forms apparently seen in the corona are in reality only optical appearances caused by concentrated beams of solar light, shining out through regions sparsely filled with finely divided dust-like particles of meteoric matter and an almost inconceivably tenuous gas?

The existence of this matter in the coronal regions is a well established fact, and that concentrated beams of solar light shin-

ing out through such matter would necessarily produce the appearance of real streamers and filaments, I think there can be no reasonable doubt.

This concentration of the solar light into separate and independent beams would necessarily be brought about, I think, by refraction in the thousands of miles of chromospheric gases underlying the corona.

It can scarcely be doubted that on account of various disturbing causes great numbers of enormous protuberations and depressions are continually rising and falling in these lower gases, rendering vast areas of their surfaces either extraordinarily convex or distinguishingly concave.

Each of these protuberations, it will be seen, would act as an enormous converging lens on the rays of light passing out through it, sending them out through the otherwise inconspicuous matter prevailing in the coronal regions in vast beams of parallel or nearly parallel rays and producing in this way the appearance of real streamers and filaments in those regions.

The depressions on the contrary, would cause such a divergence in the rays of light passing out through them that the appearance of dark rifts would be produced in the insufficiently illuminated overlying coronal regions.

The remarkable correspondence of the configuration of the corona to the zones of maximum and minimum disturbances in the chromospheric gases seem to greatly strengthen these views. It will be noticed that outside of the sun-spot zones where the chromospheric gases are usually in a comparatively quiet condition and only a small amount of refraction takes place, the structural elements in the corresponding parts of the corona are much restricted and very indefinite in their outlines. Inside of these zones, however, where violent disturbances are constantly taking place, producing numerous protuberations and depressions in the chromospheric gases, the light passing out through them is refracted in such manner that it is sent out through the coronal regions, for the most part in separate and independent beams and as a consequence we find that the structural forms in those parts of the corona are not only remarkably well defined but also much longer and more numerous than they are in other places.

The appearance of tangental, inclined, and curved streamers can be fairly well accounted for I think by refraction in the coronal gas caused by irregularities in its density. The frequent appearance in this gas, not only of heterogeneous aggregations

of meteoric matter but even of cometary bodies, all moving through it with transcendent velocities, must necessarily cause very considerable differences in its density and refractive power in different parts of the corona, as the compression of this gas by the impact of these bodies is certainly very great. It seems quite reasonable therefore that the direction of a beam of light passing out through it would very often be considerably changed on this account. It must be remembered also that quite often the line of vision between ourselves and many of these streamers passes through almost the entire volume of this gas, causing by refraction in its uneven density quite a difference between the real and apparent position of the different parts of these streamers and greatly augmenting their curved and distorted appearance. Perspective also, no doubt, often intensifies and exaggerates these distortions and causes them to appear much greater than they really are.

It will be seen, therefore, that notwithstanding the great tenuity of the coronal gas it is yet able to produce by refraction the apparent distortions which are sometimes seen in the structural forms of the corona.

OCEANA, W. Va.

OBSERVATION OF THE LEONIDS AT CLAREMONT, CAL.

F. P. BRACKETT.

FOR POPULAR ASTRONOMY.

The Leonids were observed this year by a small class in Astronomy at Pomona College. Observations were made every night between the hours of 12 and 4 from Nov. 11 to 17 inclusive. Volunteers were requested from a small senior class in astronomy, all of whom were busy with ordinary college work and had small experience in such observations. Hence no attempt was made to cover the hours before 12 or after 4. The time from 12 to 4 each night was divided into two watches of two hours each and each watch was assigned to a group of two or three observers. The program was not carried out however just as planned. Certain watches were left with only a single observer, while one group was on duty three successive nights. Each watch was divided into periods, usually of thirty minutes, in which the number of meteors seen was counted and the "time of ten" noted. Each group was urged, *first*, to keep the count of all meteors seen; *second*, to time as many as possible; *third*, to describe them; and

fourth, to sketch as many as could be carefully located. The description includes magnitude, color, duration, and if the path of the meteor was not mapped, the direction and length of its course with the name of the constellation in which it was seen, also any other peculiarities noticed.

Division of Labor. In a group of three one kept the count, noting as much of the description as possible, another kept his eye on the watch and noted the times; while the third mapped all he could, each meteor described or sketched being numbered according to the count of the first observer.

Maps. The offer of Professor Pickering* to furnish observers with blanks and maps was not noticed until too late to obtain them. Anticipating a considerable shower, and wishing to confine the observers to a small field near Leo, maps were prepared of small area having a point in Leo as centre, that is from 7^h to 13^h of right ascension and from $-20°$ to $60°$ of declination. These were first prepared according to the direction of Professor Winslow Upton in his articles of 1893 on constellation study†. Only stars above the fourth magnitude were entered. After the observations, copies were made from these by tracings and blueprints, In the tracings a circular map was taken off with centre at $\alpha = 10^h$, $\delta = 20°$ and a radius of $40°$. Thus a set of five maps was made, one each for the 12th, 13th, 14th and 15th, and one for the 16th and 17th together. But the map for the 15th, in this series, was made indirectly, as follows:—the POPULAR ASTRONOMY for November came on the 14th and the chart accompanying Professor Wilson's article was used by the observers of Nov. 15. Blue prints were made directly from this but another map uniform in size and style with those of the series was also made *from this one*, the meteor paths being transferred by calculation. This does not contain in its smaller field a considerable number which appear on the first map. A chart of larger field would have been better for the series as many meteors were observed outside of this field. Meteors are designated by the system of double numbers used in Table I.

EXPLANATION OF TABLES.

Table I‡ contains as full individual descriptions as could be obtained of a large number of the meteors seen. Some observers mapped and described nearly all, others but few, of those counted.

The two columns under "designation" indicate the number of the meteor and its observers. Each has a double number, the Ro-

* Circular No. 31, Harvard College Observatory.
† Popular Astronomy, Vol. I, pp 1 et seq.
‡ Table I is omitted because of its length and the expense of printing it.—ED.

man numeral indicating the number of the *period*, and the other that of the meteor itself. Periods were numbered chronologically from the first night through the week. The *meteor-numbers* begin anew with *one* each night and run through that night. The next column but one has the date. Thus | XII 20 | ..... | 13 | designates the 20th meteor seen on the 13th of November and in the twelfth period of the week.

The *observers* are designated thus:

A. Miss M. E. Allen.	B. Miss L. W. Bartlett.
C. Miss W. E. Clapp.	D. Miss E. E. Parker.
E. Miss M. M. Parker.	F. Mr. F. D. Fairchild.
G. Mr. C. A. Jenks.	H. Mr. J. Sibley.
J. Mr. E. P. Steffa.	K. Mr. F. P. Brackett.

Under "*Time*," *Date* is the day of November, civil time; *P. S. T.* is the Pacific Standard Time when the meteor was sighted; *Dur.* is the number of seconds it was visible. As all were quite rapid, no distinction was made between the time of flight and that of the trail, but the duration includes the whole time during which meteor or trail were visible.

Under "*Appearance*," *Mag.* represents the magnitude according to the scale suggested by Prof. Pickering, and the *color* is indicated by the initial letters, *B*—blue, *G*—green, etc.

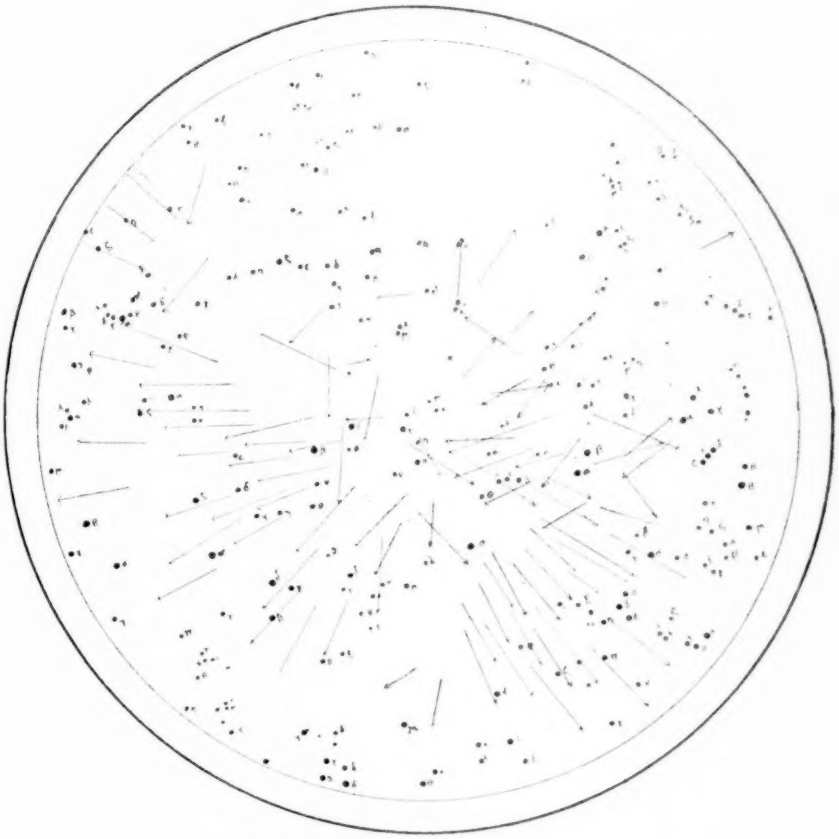
Location is given in two ways—*either* by right ascension and declination, taken from the sketch of the meteor if plotted on the chart, of its points of appearance and disappearance (given in the first four columns under *location*,) *or* by the constellation in which it was seen, its direction and the length of its course in degrees (last three columns under *location*).

TABLE II groups the results by *periods*. The first four columns are the civil date, the number of the period, the duration of the period in minutes and the Standard Pacific Time of the *beginning* of the period. The "*Time of Ten*" is the time which elapsed from the beginning of the period until ten were counted.

There are four columns of *numbers*, the total number counted, the number of Leonids, the number described in Table I and the number sketched on the charts ("*maps*"). As only those *known* to be Leonids were counted as such, this number is too small and should be increased perhaps one half.

The *position of the radiant* for each night was formed by extending the lines of meteor tracks back to their intersection with other similar lines and then *judging* the centre. When a number of centres were noticeable, these were noted as *sub-radiants* and

their several locations, together with the number of meteors in each, taken into consideration in determining the *chief radiant* of the night.



LEONIDS CHARTED AT POMONA COLLEGE, CLAREMONT, CAL., BY PROFESSOR F. P. BRACKETT AND CLASS, NOV. 15, 1898.

The two columns under "*Observed*" give the *observers* ("*By*") with the same designation as in Table I, and the *field* to which their attention was directed. *E 150 x 75* means that part of the sky having the Prime Vertical as centre and extending 75° in azimuth on either side and 75° in altitude from the horizon

East or *E* means the eastern half of the sky, *Leo* as much as could be seen with Leo *continually* in the centre of the field.

TABLE II—RESULTS OF OBSERVATIONS BY PERIODS.

Date (Nov.)	Group No.	Duration.	P.S.T. at beginning.	Time of Ten.	Number of Meteors Observed. Total.	Leonid.	Table I	Map.	Position of Radiant.	Observed. By	Field.
		h	h m	m					h m °		
9	I	15.	11 05		8	0	1	0		K	E 150x75
11	II	120	12 00		15	0				H	East
12	III	30	12 00	27	10	1				K	E 150x75
12	IV	30	12 57		6	1	2	2		K	E 150x75
12	V	25	2 10	25	10	7			9 50 −22	C.D.E.	E
12	VI	20	2 35	20	10				7 30 −22	C.D.E.	E
12	VII	25	2 55	25	10				7 25 7	C.D.E.	E
12	VIII	35	3 20		7					C.D.E.	E
13	IX	30	12 15		3		3	3	9 50 to 22	F.G.J.	Leo
13	X	30	12 45		8	1	8	8	10 00	"	"
13	XI	30	1 15		8	3	7	7	sub-radiants	"	"
13	XII	30	1 45	18	14	3	13	13	10 15 25	"	"
13	XIII	30	2 15	21	10	2	10	10	9 00 24 30	"	"
13	XIV	30	2 45	23	10	3	9	9	9 50 22	"	"
13	XV	30	3 15	23	13	3	13	15	10 30 17	"	"
13	XVI	30	3 45	19	12	6	11	11	9 45 22 30	"	"
14	XVII	30	12 20	23	13	1	0	0		E	S.E.
14	XVIII	30	12 20		9	3	5	4	for the 14th	A.G.	W
14	XIX	30	12 20		3	0	3	2	10 3 30 22 20	K	N.E.
14	XX	30	12 39	25	11	1	11		sub radiant	J	S.W.
14	XXI	30	1 00	30	35		20		9 45 22 30	A.E.G.K	Entire
14	XXII	15	1 45	17	15		6	2		A.E.K.	"
14	XXIII	30	1 09	23	12	3	10	10		F.J.	Leo
14	XXIV	30	1 39	23	10	3	9	9		"	"
14	XXV	30	2 15	19	14	3	12	12		"	"
14	XXVI	30	2 45	23	12	1	10	10		"	"
15	XXVII	30	1 15	10	26	19	24	24	for the 15th	F.G.J.	"
15	XXVIII	30	1 45	11	26	13	22	22	10 17 30	"	"
15	XXIX	30	2 15	5	40	31	28	28	sub-radiants	"	"
15	XXX	30	2 45	12	22	13	20	20	10 05 15	"	"
15	XXXI	30	3 15	8	33	20	33	2	9 50 22 30	"	"
15	XXXII	30	3 45	10	25	13	21	0	10 10 24	P.J.	"
16	XXXIII	30	2 34		9	4	2	3	10 13 for the 16th	A.D.	East
16	XXXIV	30	3 10		9	4	6	3	9 50 23	"	"
16	XXXV	30	3 43		4	4	4	3		"	"
17	XXXVI	30	1 29	20	12	4	12	12	for the 17th	B.E.	"
17	XXXVII	30	2 04	22	13	4	13	13	10 10 22 ± 2	"	"
17	XXXVIII	15	2 37		3	2	3	3		"	
			Totals		510	173	355	260			

Some Conclusions and Results of the Observations.

The weather was uniformly favorable, not too cold and neither cloudy or foggy. But the *number* of *meteors seen* was much less than expected and the *proportion* of *Leonids* smaller. Strictly

speaking, there was no "shower." Not including those seen when off duty, 510 were counted in all, of which perhaps 250 were Leonids. Of these 355 were more or less fully described and 260 charted.

The *frequency* of their appearance may be learned from the P. S. T. column of Table I or from the "*Time* of *Ten*," Table II. Only once was more than *one* visible at the same time, so as to make the enumeration difficult.

On the 13th, 78	were seen in	4	hours—	average	interval	about	3^m		
" " 14th, 134	"	"	"	3	"	—	"	"	"	1.34
" " 15th, 172	"	"	"	4	"	—	"	"	"	1.34

During the hours of greater frequency these intervals varied from 1 or 2 seconds to 5 minutes. The time of *maximum frequency* occurred at $2^h\ 27^m\ 15.18^s$ on the 15th P. S. T. when a dozen were seen in 3 seconds. Other maxima occurred about 2 o'clock on the 13th and between 1:00 and 1:30 on the 14th.

A large part of the meteors seen were of the third and fourth *magnitudes*, about forty of first magnitude, five of 0 magnitude and one each of magnitudes — 1 and — 2.

Less than ten per cent. were *visible* more than half a second and only *nine* over a second.

Few had paths which were appreciably curved.

Scarcely any were explosive. No noise was heard from any. No comparisons have been made with other observers in this vicinity to determine the real proximity of any.

In drawing and copying the maps and in preparation of the tables much of the work has been done by Mr. C. A. Jenks, Mr. F. D. Fairchild and Mr. E. P. Steffa.

POMONA COLLEGE, Claremont, Cal.

ASTRONOMICAL PHENOMENA DURING 1899.

H. C. WILSON.

ECLIPSES.

In 1899 there will be five eclipses, three of the Sun and two of the Moon, none of them possessing any very great interest to American astronomers.

1. *A Partial Eclipse of the Sun*, Jan. 11, will be visible in the northern part of the Pacific Ocean. It will be visible just at sunset in the northwestern corner of the United States and in Alaska, and at sunrise in Japan and along the eastern coast of Siberia.

2. *A Partial Eclipse of the Sun*, June 7, will be visible in north polar regions. It will be visible in Alaska, Greenland, the northwestern part of Europe and the northeastern part of Asia.

3. *A Total Eclipse of the Moon* June 22-23, will be visible throughout the Pacific Ocean. The beginning will be visible in the western portion of North America and the eastern portion of Asia, the end in Asia and the eastern portion of Africa.

TIMES OF THE PHASES.

		G. M. T. h	m
Moon enters penumbra	June 22	23	36.4
Moon enters shadow	23	0	32.9
Total eclipse begins	23	1	32.8
Middle of Eclipse	23	2	17.9
Total eclipse ends	23	3	2.9
Moon leaves shadow	23	4	2.7
Moon leaves penumbra	23	4	59.5

The magnitude of the eclipse, i. e., the greatest depth of immersion of the Moon into the Earth's shadow, will be 1.488 (times the diameter of the Moon).

4. *An Annular Eclipse of the Sun*, Dec. 2, will be visible in the regions about the south pole. It will be visible as a partial eclipse on a small part of Australia and the Islands of New Zealand.

5. *A Partial Eclipse of the Moon*, Dec. 16, will be visible generally throughout Europe and Africa and the eastern part of North America. The beginning will also be visible in Asia and the ending in the western part of North and South America.

TIMES OF THE PHASES.

		G. M. T. h	m
Moon enters penumbra	Dec. 16	10	32.9
Moon enters shadow		11	44.9
Middle of eclipse		13	26 0
Moon leaves shadow		15	6.7
Moon leaves penumbra		16	18.8

The magnitude of the eclipse will be 0.996, almost total.

OCCULTATIONS.

The *American Ephemeris* gives a list of 109 occultations of stars by the Moon, which will be visible at Washington during the year. Most of these will be visible in part or wholly throughout the United States. We will give the list for each month in POPULAR ASTRONOMY. The list for January is given herewith:

Occultations Visible at Washington.

Date 1899.	Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle f'm N pt. °	EMERSION. Washington M. T. h	m	Angle f'm N pt. °	Duration. h	m
Jan. 1	36 Sextantis	6.6	14	55	102	16	14	333	1	19
2	*e* Leonis	5.3	15	42	142	17	6	293	1	24
3	14 Virginis	6 9	18	52	179	19	39	248	0	47
20	33 Tauri	6.3	14	5	115	14	55	245	0	50
23	10 Geminorum	7.0	3	54	60	4	49	295	0	55
23	11 Geminorum	7.3	4	2	93	5	5	263	1	3
24	61 Geminorum	6.0	15	11	151	16	4	255	0	53
25	ζ^1 Cancri	4.8	12	20	113	13	46	305	1	26
27	*o* Leonis	3.8	9	6	86	10	14	326	1	8

THE PLANETS.

The two charts, Fig. 1, show the apparent paths of the planets Mercury and Venus around the heavens during the year 1899. It may be interesting to

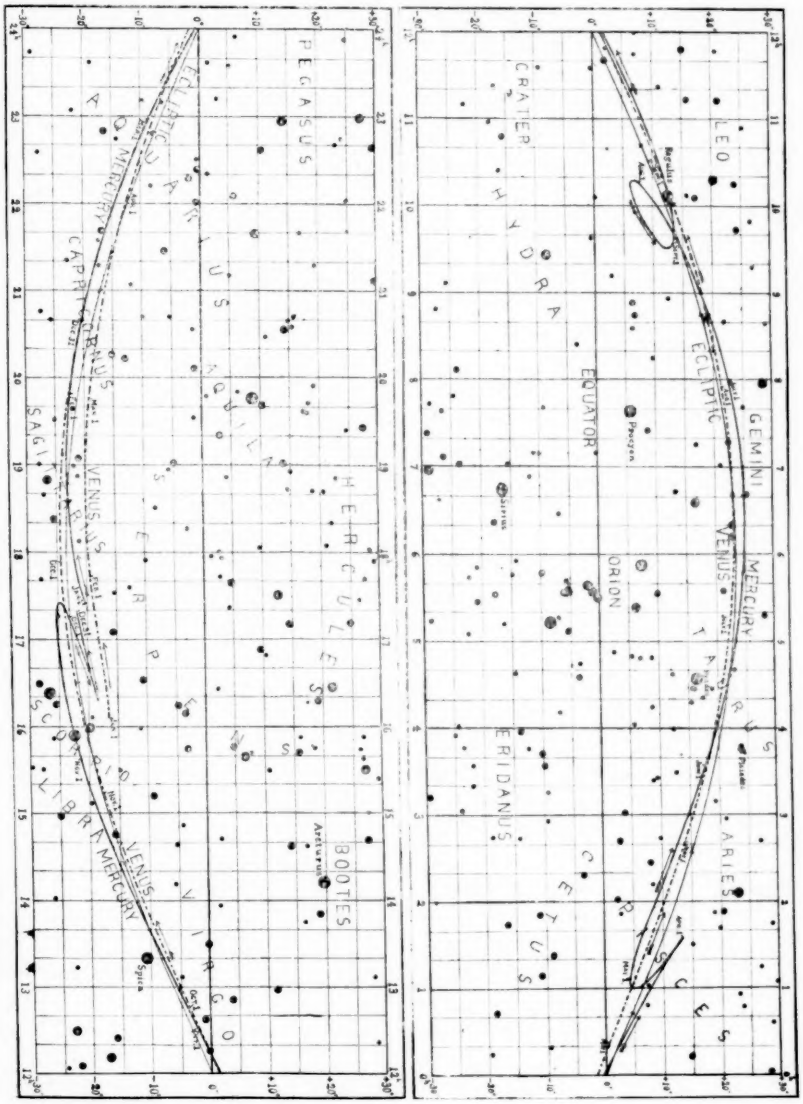


FIG. 1. CHART OF THE APPARENT PATHS OF MERCURY AND VENUS DURING 1899.

the reader to compare these charts with those which we published last year, Vol. V., p. 493, and notice the changes in the paths of the two planets. The heavy smooth line represents the course of Mercury and the dotted line that of Venus. The places of the planets on the first day of each month are marked upon the chart. Also the place of the Sun upon the ecliptic is marked by a cross for the first day of each month but the dates are not written in. If the reader will note that the Sun is in Sagittarius on Jan. 1; in Capricorn, Feb. 1; Aquarius, Mar. 1, etc., he will have no difficulty in locating the place of the Sun with reference to the planets.

Mercury begins the year in Sagittarius, about 20° west of the Sun, and moves eastward, overtaking the Sun in the last days of February. About April 1 the planet becomes stationary in right ascension and then turns westward, sweeping toward the south as it passes the Sun at inferior conjunction, and then turns eastward again in the latter part of the month. In August, Mercury again passes between Earth and Sun and its apparent path in the sky is a closed loop like that described last year in August, but about 15° farther toward the west. Still a third loop is described in December when the Sun is in Scorpio. The sharpness of the turns made in April and December as compared with the corresponding movements last year is worthy of notice. Mercury is, of course, always in the vicinity of the Sun and is only visible to the eye for a few days, when at its greatest elongation east or west of the Sun. These greatest elongations will occur as shown in the following table in 1899:

ASPECTS OF MERCURY.

Jan. 11.	Greatest elongation west	23°	38′
Feb. 27.	Superior conjunction		
Mar. 24.	Greatest elongation east	18	45
April 12.	Inferior conjunction		
May 9.	Greatest elongation west	26	15
June 14.	Superior conjunction		
July 22.	Greatest elongation east	27	0
Aug. 19.	Inferior conjunction		
Sept. 5.	Greatest elongation west	18	1
Sept. 30.	Superior conjunction		
Nov. 16.	Greatest elongation east	22	27
Dec. 5.	Inferior conjunction		
Dec. 25.	Greatest elongation west	22	11

The path of *Venus* will be a straightforward smooth curve, a retrograde movement having been completed in December, 1898, and the next not occurring until some time in 1900. Venus will be visible as "morning star" until September and during the latter part of the year will be seen in the evening.

The chart, Fig. 2, shows the apparent paths of *Mars*, *Jupiter* and *Saturn*, during 1899. Mars begins with retrograde motion from Cancer to Gemini, completing the loop begun in December, 1898, and after Mar. 1 describes a smooth curve, first north then south of the ecliptic, ending Dec. 31 in Sagittarius, a little east of the Sun. Mars will be at opposition Jan. 19 and will be in good position for observation during the first half of the year.

Jupiter's course lies between Virgo and Scorpio, advancing at first, retrograding from March to July, and after that advancing until the end of the year. Saturn pursues a similar course between Scorpio and Sagittarius, moving eastward for the first three months, westward until the middle of August and eastward for the remainder of the year. Jupiter will be in best position for observation in May, June and July, Saturn in July, August and September.

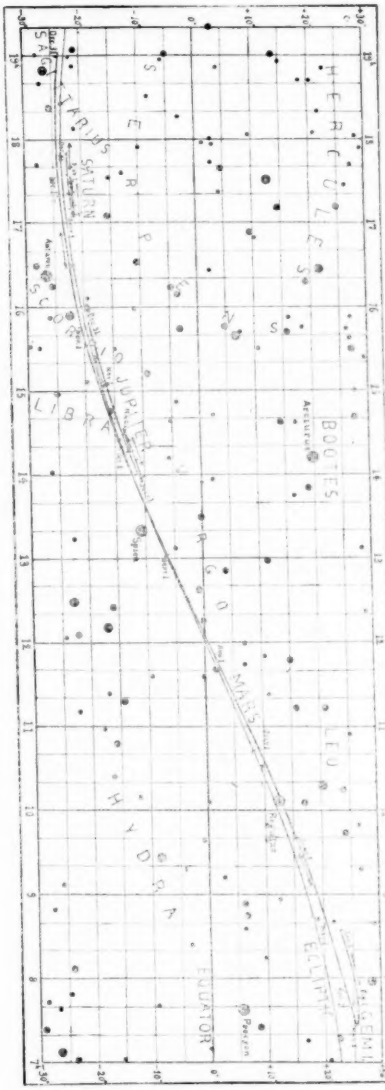


FIG 2. CHART OF THE APPARENT PATHS OF MARS, JUPITER AND SATURN DURING 1899.

Uranus and Neptune, being invisible to the eye, we have omitted from the charts, and will later give diagrams of their paths on a larger scale, showing their position relative to the telescopic stars in their vicinity.

COMETS.

Three periodic comets are due to return to perihelion in 1899. They are all telescopic comets and cannot be expected to be bright this year.

Barnard's comet, 1892 V, which by an error we included in last year's list, is due at perihelion in April 1899, but will be on the farther side of the Sun and so is not likely to be found.

Holmes' comet, 1892 III, which behaved so curiously in 1892 and 1893 in its changes of form and brightness, is due at perihelion about May 9, but will not be in good position for observation until the autumn or winter.

Tempel's second periodic comet, first seen in 1873, and observed again in 1878 and 1894, will return this year under circumstances very favorable for its observation. The comet will reach perihelion in July when its distance from the earth is comparatively small. For several months after that the Earth and comet will be moving in almost parallel courses and the distance will increase slowly.

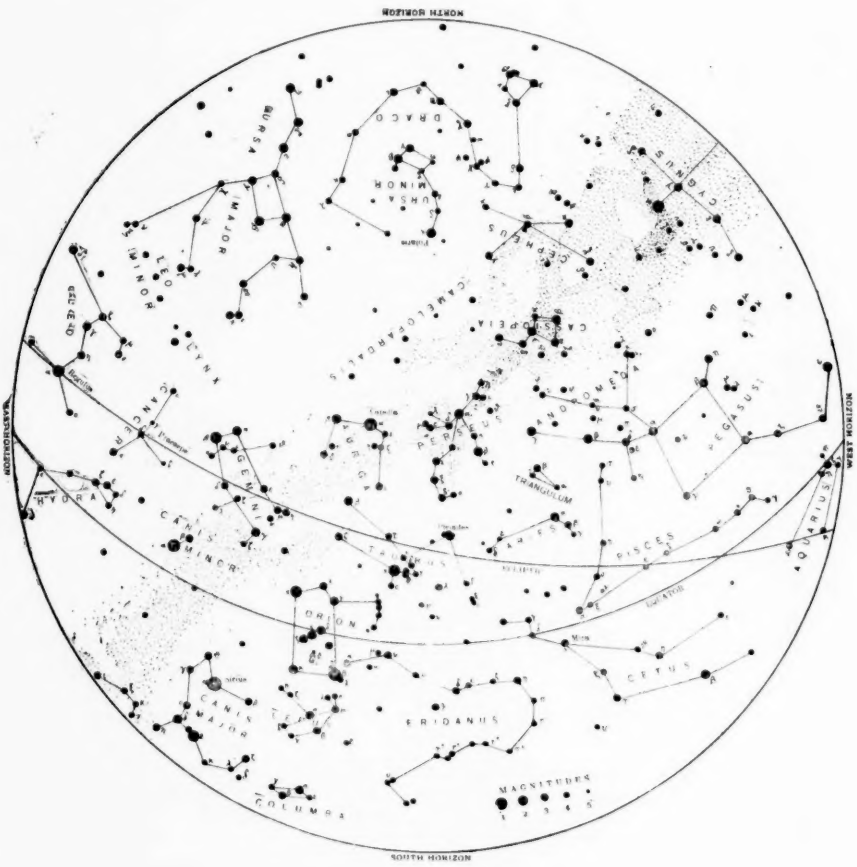
Finlay's comet, 1886 VII, seen at its return in 1893, is due again at perihelion early in 1900, but will then be nearly opposite the Sun. It may possibly be seen during the summer of 1899 with the aid of the great telescopes.

New comets may be expected at any time. The past year has been a very fruitful one in comet discovery, no less than ten, three old and seven new, having been observed.

METEORS.

The great Leonid shower in November will be looked forward to with great interest, since it is likely to approximate the wonderful showers of

1833 and 1866. The exact time of the maximum of the shower is somewhat uncertain, on account of the perturbations of the orbit of the swarm by the planets Saturn and Jupiter during the last few years.



THE CONSTELLATIONS AT 9 P. M., JANUARY 1, 1899.

The general effect of the perturbations has been to increase the distance between the earth's orbit and the axis of the meteor stream and delay the time of nearest approach about one day. The shower should be looked for on the nights of Nov. 14-16, most probably being at maximum on the morning of the 16th.

In the *Companion to the Observatory* for 1899, just received, Mr. W. F. Denning gives a list of 90 radiant points of the principal meteor showers of the year. Nine of the more brilliant showers are given below:

	Constellation.	Radiant. R. A. °	Decl. °	Meteors.
Jan. 2	Draco	230	+ 53	Swift; long paths.
April 20	Hercules	270	+ 33	Swift.
May 6	Aquarius	338	− 2	Swift; streaks.
July 28	Aquarius	339	− 12	Slow; long.
Aug. 10	Perseus	45	+ 57	Swift; streaks.
Oct. 18	Orion	92	+ 15	Swift; streaks.
Nov. 14-16	Leo	150	+ 22	Swift; streaks.
Nov. 23-27	Andromeda	25	+ 44	Very slow; trains.
Dec. 10	Gemini	108	+ 33	Swift; short.

The Perseids, with maximum Aug. 10, are visible for a considerable period, and the radiant exhibits an easterly motion among the stars, changing from R. A. 19°, Decl. + 51°, July 19, to R. A. 53°, Decl. + 58°, Aug. 16.

VARIABLE STARS.

J. A. PARKHURST.

Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time.]

1899.

U CEPHEI.

	d	h
Feb.	2	9
	4	20
	7	8
	9	20
	12	8
	14	20
	17	7
	19	19
	22	7
	24	19
	27	7

ALGOL.

	d	h
Feb.	2	20
	5	17
	8	14
	11	11
	14	7

ALGOL Con.

	d	h
	22	22
	25	19
	28	16

λ TAURI.

	d	h
Feb.	9	21
	13	20
	17	18
	21	17
	25	16
	29	15

R CANIS MAJ.

Every 8th min.
P = 1^d $3^h.3$

	d	h
Feb.	8	17
	19	17
	26	21

S CANCRI.

	d	h
Feb.	10	9
	19	21
	29	8

S VELORUM.

	d	h
Feb.	2	21
	8	20
	14	18
	20	16
	26	15

δ LIBRÆ.

	d	h
Feb.	6	16
	9	0
	13	15
	15	23
	20	15
	22	23
	27	15

U CORONÆ.

	d	h
Feb.	7	19
	14	17
	21	15
	28	12

U OPHIUCHI.

Every 10th min.
P = $20^h.1$

	d	h
Feb.	1	3
	9	13
	17	22
	26	7

Sawyer's new Algol-type variable, of which particulars were given in the December POPULAR ASTRONOMY and *Astronomical Journal* No. 450, will be too near the Sun to be observed in February.

No ephemeris of long period variables has appeared at the present writing.

NEW VARIABLES DISCOVERED IN 1898. The following list, which cannot claim completeness, will give an idea of the progress made during the past year. Of these stars, the following five have been assigned letters and numbers by Dr. Chandler:

	h	m	s	°	′	
Espin 911	20	29	55	+54	37.6	7379 ST Cygni
SDM −20°.2007	7	28	18	−20	26.7	2689 Z Puppis
DM 30 ,1329	6	40	43	+30	22.6	2404 X Geminorum
— —	6	35	56	+58	0.5	2376 S Lyncis
DM +67 ,1124	19	9	57	+67	6.9	6899 U Draconis.

NEW VARIABLES DISCOVERED IN 1898.

Star.	Place 1900					Observed Range.		Discoverer.	Reference.
	R. A.			Decl.					
	h	m	s	°	′	M	M		
DM +45°.624	2	26	59	+45	12.8	8.2	9.5	Es.	AN. 3472, 82
C. Z. II, 1547	2	57	40	−51	2 2	8.1	—	Kap	AJ. 442
DM +20°.1083	5	39	42	+20	39.1	7.7	8.9	Köhl.	AN. 4475,82,89
DM +30.591	3	49 1		+30	46	6.31	6.92	M & K	AJ. 434
DM +30,1329	6	40	43	+30	22.6	8.3	11.75	An.	AN 3463
	6	35	56	+58	0.5	9.5	13	An.	AN 3467
	6	50.2		+67	17.4	9-10	12	Ge.	AN 3493
	6	50.3		+67	18 0	9-10	12	Ge.	AN 3493
SDM −20°,2007	7	28	18	−20	26.7	—	—	Pe.	AJ 398, 428
	8	9	14	−34	16.6	6.8	7.8	Kap.	AJ 442
	9	40	25	−23	33 6	9.6	11.8	Kap.	AJ 442
	10	46	33	−28	6.1	8.5	11	Kap.	AJ 442
CDM −32, 8314	11	42	37	−32	42.8	8.9	9.55	Kap.	AJ 442
OA 13441	14	5	48	−28	24.8	8 8	12	Kap.	AJ 442
CZ XV, 3719	15	54	29	−29	38.3	9.1	10 7	Kap.	AJ 442
CPD	16	43	11	−19	17.1	8.7	11.5	Kap.	AJ 442
DM +12°.3557	18	26	1	+12	32.6	7 0	7 5	Sa.	AJ 447
DM +67,1124	19	9	57	+67	6 9	9 0	12.7	An.	AN 3463
DM +20.4200	19	32	15	+20	6 6	6.94	7.61	M & K	AJ 432
DM +28,3460	19	40	49	+29	1.2	6 57	7.37	M & K	AJ 432
Esp-Birm 649	20	6	17	+41	12	8 9	10 2	Es.	AJ 426
	20	8	3	+12	41.7	9.3	12	An.	AN 3520,1
Espin 911	20	29	55	+54	37.6	9	14	Es.	AJ 433
	21	3.7		+82	34 9	10	12	Cer.	AN 3512
	21	16	15	+14	14.4	9.1	12	An.	AN 3521
DM +68°,350	—	—		—		8.0	9 3	Ge.	AN 3493

In the column headed "Observed range" the latest available data have been used, showing the greatest range published up to the present time. In the column, "Discoverer" the following abbreviations have been used: Es.—Rev. T. E. Espin, Tow Law, England. Kap.—Dr. J. C. Kapteyn, Groningen, Holland. Köhl,—Torvald Köhl, Odder, Denmark. M & K.—Professors Müller and Kempf, Potsdam, Germany. An.—Rev. Thos. D. Anderson, Edinburg. Ge.—Professor H. Geelmuyden, Christiania, Sweden. Pe.—Mr. Arthur C. Perry, New York. Sa.—Mr. Edwin F. Sawyer, Brighton, Mass. Cer.—Professor W. Ceraski, Moskow. In the column "Reference," AN stands for *Astronomische Nachrichten*, and AJ for *Astronomical Journal.*

In addition to the above 26, the lists announced by the Harvard College Observatory need not be repeated here, since they have been published in Vol. VI of POPULAR ASTRONOMY. In Circular No. 24, published on page 15, 27 new variables are announced, besides those in clusters; and in Circular No. 32, on page 363, 9 are announced, making 36 from the H. C. O. and a total of 62 for the year.

The number of new variables discovered in clusters may be judged from the fact that in Circular No. 24, dated 1898 Jan. 31, 437 variables are mentioned as known, and in No. 33, dated Sept. 17, 509 are recorded, a gain of 72 during three-quarters of the year. This shows a successful activity in this field, which perhaps has not been exceeded, if equaled, in any previous year.

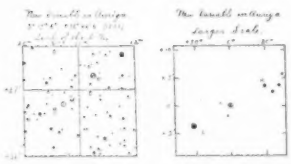
SS CYGNI. The November maximum was well enough observed to give a good determination of its features. Following are the observations of Zaccheus Daniel and J. A. Parkhurst:

Gr. T.	m		Gr. T.	m	
Nov. 7.51	11.30	P	Nov. 15 57	8.98	D
7.55	11.32	D	15.52	8 88	P
8.68	11.42	D	16.52	9.30	P
10.52	10.70	P	17.61	9.84	D
10.58	10.53	P	18.51	10.20	D
11.50	8.65	P	19.49	10.47	P
11.63	8 65	D	20.50	11.08	P
12.51	8 50	P	20.62	11.08	D
12.56	8.46	D			

Inspection of the curve shows that this was a typical "short" maximum with the following particulars:

Rise began	Nov. 10.0	
Passed $9^m.35$	" 11.1	
Maximum	" 13.0	
Reached normal mag.	" 21 1	
Above normal mag.	11.1 days	
Previous normal period	47 days	
Interval between passing	9 35 mag.	66.7 days
" " maxima		64 days.

CERASKI'S NEW VARIABLE.—This was announced by Professor Ceraski in the *Astronomische Nachrichten*, No. 3529. It was discovered from a photograph and found to be 8 or 9 magnitude in April, 1898, but in October was invisible in his "seven-foot" telescope. Dec. 10 I found it 9th magnitude, and measured its position relative to the two Durchmusterung stars, marked *a* and *c* on the chart, which are + 36°, 1135 and 1141, respectively. The resulting place of the variable is



R. A. $5^h\ 17^m\ 6^s$, Dec. + 36° 46'.6, (1855)
$20\ \ 9$ 49 .3, (1900)

The positions of the following comparison stars were also measured, the magnitudes of *a* and *c* are from the DM, the others are estimated for identification.

COMPARISON STARS FOR CERASKI'S NEW VARIABLE IN AURIGA.

	Co-or. from the Var. R. A.		Decl.	Mag.		Co-or. from the Var. R. A.		Decl.	Mag.
	′	″	′			′	″	′	
f	−9.3	−46 5	+5.7	9 5	*g*	−1.4	− 7.0	+3.8	10.5
e	−8.7	−43.4	+3.7	9.5	*l*	+0 3	+ 1.5	−1.9	11
d	−7.6	−38.1	+2.5	9.5	*k*	+1.8	+ 8.8	+0.5	12
a	−6.1	−30.4.	+3 6	9.5	*c*	+6.7	+33.4	−3.9	8.9
h	−1.5	− 7.4	+1.8	12					

As will be seen from the chart, the variable is about 40′ south following the 5.2 magnitude star *sigma* Aurigæ, and can be easily found without position circles. This should be added to the list of variables near naked eye stars, given in POPULAR ASTRONOMY, V, 389.

COMET NOTES.

Elements of Comet j 1898 (Chase).—Several sets of elements have been calculated for this new comet, the latest at hand being by Mr. S. C. Chandler, and depending upon positions determined Nov. 25 and Dec. 7. These places are represented very closely by a parabolic orbit.

ELEMENTS OF COMET *j* 1898.

$$\left.\begin{array}{rl} T = & 1898\ \text{Sept.}\ 18.132 \\ \omega = & 3^\circ\ 51'\ 57''.4 \\ \Omega = & 95\ \ 52\ \ 17\ .1 \\ i = & 22\ \ 29\ \ 58\ .0 \end{array}\right\} 1898.0$$

$$\log q = 0.358248$$

Equatorial co-ordinates 1898.0

$$x = [9.966007]\, r \sin (190^\circ\ 13'\ \ 2''.2 + v)$$
$$y = [9.974676]\, r \sin (108\ \ 32\ \ 31\ .1 + v)$$
$$z = [9.703260]\, r \sin (\ 55\ \ 29\ \ 46\ .1 + v)$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1898.	R. A.			Decl.			Br.
	h	m	s	°	′		
Dec. 9.5	10	42	39	+ 25	10.5	0.3054	1.10
11.5		44	57	25	25.7		
13.5		47	10	25	41.5	0.2998	1.11
15.5		49	19	25	57.7		
17.5		51	21	26	14.4	0·2947	1.12
19.5		53	17	26	32.2		
21.5		55	6	26	50.4	0.2940	1.13
23.5		56	50	27	9.2		
25.5		58	27	27	28.6	0.2851	1.14
27.5	10	59	57	27	48.6		
29.5	11	1	22	+ 28	9.2	0.2810	1.15

Orbit of Comet 1895 II.—In *Astronomical Journal*, No. 451, Mr. Herbert R. Morgan, of the Leander McCormick Observatory, Charlottesville, Va., gives the results of a determination of the orbit of Comet 1895 II from all the published observations The number of observations used was 319, from which seven normal places of the comet, about a month apart, were deduced. The elements represent these normal places within the probable errors of the observations.

ELEMENTS OF COMET 1895 II.

Epoch = 1895 Aug. 24.5 Greenwich M. T.

$$\left.\begin{array}{rl} M = & 0^\circ\ 30'\ 10''.75 \\ \omega = & 167\ \ 46\ \ 9.96 \\ \Omega = & 170\ \ 18\ \ 24.97 \\ i = & 3\ \ 0\ \ 26.71 \end{array}\right\} 1895.0$$

$$\varphi = 40\ \ 43\ \ 47.25$$
$$\mu = 491''.5091$$
$$\log a = 0.5723167$$

Ephemeris of Wolf's Comet 1898

[From *Astronomische Nachrichten*, No. 3518.]

1898.		α		δ		log *r*	log Δ	Ab.-Time.		Bright-
	h	m	s	°	′			m	s	
Jan. 1	6	33	49	— 16	59.7	0.3684	0.1750	12	25	1.76
2		32	53	16	57.4					
3		31	59	16	54.7	0.3707	0.1788	12	51	1.72
4		31	5	16	51.6					
5		30	11	16	48.1	0.3729	0.1827	12	38	1.67
6		29	18	16	44.2					
7		28	27	16	40.0	0.3751	0.1869	12	46	1.62
8		27	36	16	35.3					
9		26	46	16	30.0	0.3773	0.1912	12	53	1.57
10		25	57	16	24.7					
11		25	10	16	19.2	0.3795	0.1957	13	1	1.52
12		24	24	16	13.3					
13		23	40	16	7.0	0.3817	0.2004	13	10	1.47
14		22	57	16	0.4					
15		22	14	15	53.5	0.3838	0.2052	13	19	1.42
16		21	34	15	46.4					
17		20	55	15	39.0	0.3860	0.2102	13	28	1.38
18		20	16	15	31.6					
19		19	38	15	23.1	0.3882	0.2154	13	37	1.34
20		19	5	15	14.9					
21		18	35	15	6.3	0.3903	0.2207	13	47	1.30
22		18	4	14	57.6					
23		17	33	14	48.8	0.3924	0.2261	13	58	1.25
24		17	5	14	39.8					
25		16	38	14	30.4	0.3946	0.2316	14	9	1.20
26		16	14	14	21.0					
27		15	51	14	11.5	0.3967	0.2372	14	20	1.15
28		15	30	14	1.7					
29		15	9	13	51.7	0.3988	0.2431	14	31	1.11
30		14	51	13	41.7					
31	6	14	37	— 13	31.8	0.4009	0.2489	14	43	1.08

GENERAL NOTES.

Subscribers will please bear in mind, that volume VII of this publication, which begins with this issue, will consist of ten numbers and run even with the calendar year 1899. If those who subscribe through news agents will make this very plain to them, much unnecessary correspondence will be saved.

Some new things are in store for our readers, for this year, that can not now be spoken of definitely because arrangements for them are not yet complete; but if we are successful in present plans, POPULAR ASTRONOMY for the future will be materially improved in some respects.

Numbering of Recent Asteroids.—In *Astronomische Nachrichten* No 3526 permanent numbers are given to recently discovered asteroids as follows:

No.	Temporary Designation	Discoverer	Date of Discovery	Name
(429)	1897 DL	Charlois	1897 Nov. 25	
(430)	DM	Charlois	Dec. 18	
(431)	DN	Charlois	Dec. 18	
(432)	DO	Charlois	Dec. 18	
(433)	1898 DQ	Witt	1898 Aug. 13	
(434)	DR	Wolf	Sept. 11	Hungaria

1898 DP, discovered by Charlois 1898, July 16, did not receive a sufficient number of observations to determine its orbit.

Six New Asteroids.—Six new asteroids were discovered in November by Professor Max Wolf and his assistants at Königstuhl, Germany. All were discovered photographically.

		Königstuhl M. T.			R. A.			Decl.			Magnitude
			h	m	h	m	s	°	′		
1898	DV	Nov. 6	11	18.0	3	10	8	+ 20	50		12
	DW	6	11	18.0	3	4	40	+ 18	15		12
	DX	6	11	18.0	3	2	24	+ 17	15		12
	DY	13	12	54.0	3	39	0	+ 17	59		13
	DZ	19	10	26.0	3	20	16	+ 19	2		12
	EA	19	13	39.0	2	57	12	+ 15	30		12 5

Two New Asteroids.—Two new asteroids were discovered upon photographic plates taken by Mr. E. F. Coddington at Lick Observatory, Oct. 13, 1898. They were observed Oct. 14 with the 12 inch equatorial.

		Mt. Hamilton M. T				R A.			Decl.			Mag.
			h	m	s	h	m	s	°	′	″	
1898	EB	Oct. 14	13	22	48	1	4	43.63	+ 8	33	54.3	11.5
	EC	14	15	16	49	1	0	52.61	+ 9	40	24.4	12.5

The November Meteors in 1898.—Observations of the Meteoric Shower of November 13, 1897, were made at the Harvard College Observatory, and a description of the results will be found in the Annals, Vol. XLI, No. 5, and in Circular No. 31. More extensive observations were made in 1898, and the results will be published later in the Annals. Several investigations were undertaken, and some of the preliminary results are given below. As proposed in Circular No. 31, stations have been selected all around the Earth in order that counts of the number of meteors visible might be made during the entire time that the Earth traversed the meteor stream. The density of different portions of the stream would thus be determined. Reports from the distant stations will not be received for some time. The night of Nov. 13 was cloudy in Cambridge, but on November 14, 800 meteors, not including duplicates, were recorded at this Observatory by 30 persons. The maximum occurred at three o'clock in the morning, when 61 meteors east of the meridian were counted in half an hour. 227 trails of 80 different meteors, within 30° of the radiant point, were charted. Similar observations were made at Providence by Professor Upton of the Ladd Observatory, aided by a number of students. The vicinity of the radiant was watched continuously by at least ten observers, who recorded 400 meteors. This station is 40 miles south of Cambridge, and was selected as suitable for determining the parallax visually. Ninety-six photographs were taken at Cambridge with the Draper telescopes and with eleven smaller instruments. Five photographic doublets were mounted equatorially and photographed the region within 30 degrees of the radiant, during nearly the entire night. Two cameras were carried to Tufts College, two miles north of Cambridge, and twenty-five photographs were taken simultaneously at both stations for a photographic determination of the parallax. In all, 31 trails of eight different meteors were photographed, of which 3 appeared on one plate. Four meteors were photographed at both stations, and can be used for determining the parallax photographically. The changing distance of the meteors is obvious by inspection of these photographs. A pre-

liminary determination of the radiant was made by prolonging the trails of 4 meteors. They nearly intersect at a point, the greatest deviation not exceeding 1 mm., or 10′. The position of the radiant reduced to 1900 is thus given as R. A. = $10^h\ 6^m.8$. Dec. = + 22° 16′, which is 9^m following, and 38′ south of the place given by Denning. Seventeen plates were taken with prisms, but they failed to show the spectra of any meteors. It appears from the photographs that the light of the meteors attained a maximum and then diminished as rapidly as it increased. In some cases; sudden changes due to explosions are well shown. The trail is sometimes surrounded by a sheath of light, and in one case the trail remaining after the meteor had passed was photographed. These results show that meteoric showers may now be studied to advantage by photography.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY, Circular No. 35.
November 19, 1898.

Leonid Meteors Observed at Lawrence University, Appleton, Wis.—One interesting meteor was observed on the morning of the 15th at 1:50 standard time. As near as I could locate it on the chart it appeared at R. A. $10^h\ 6^m.3$ and Decl. 18°, and disappeared at R. A. $10^h\ 15^m$ and Decl. 15°.

A little beyond the middle of its path it seemed to explode, but did not throw off any fragments that could be seen. It seemed suddenly to expand greatly and then bend downward, forming an inverted Meerschaum pipe with thick straight stem. It was very bright, and left a streak visible for three minutes. It seemed at first to drift, or rather waver, for a few seconds, then remained at rest, gradually fading away.

Name of observers, F. E. Millis and H. C. Logan. Postoffice address, Appleton, Wis.

Latitude 44° 15′ 37.7″. Longitude $5^h\ 53^m\ 35.76^s$. Condition of sky, clear.

Date.	Frequency of Meteors.		
1898	Time Begin.	Time End.	No. of Meteors.
Nov. 15	12-10 A. M.	12-40 A. M.	20 Leo.
	12-50 "	1-20 "	15 "
	1-35 "	2-05 "	21 "
F. E. Millis observing alone.			Leonids.
Nov. 15	2-25	2 55	23
	3 00	3 30	24
	4-30	5 00	18

All the above observations were made from an east window in the second story of our Observatory. From 4:30 to 5:00 nearly all the meteors going west, ward from Leo were obscured by the projection of the roof of the building.

I looked for Leonids for a short time on the mornings of Nov. 10, 11 and 12 every morning being hazy, so much so that only bright stars were visible. No meteors were seen that were *certainly* Leonids. On the 11th I saw *one* and on the 12th *four* which might have been Leonids. 12, 13 and 27th cloudy.

F. E. MILLIS.

Leonids Observed at Simpson College, Indianola, Ia.—On the night of Nov. 13, Mr. O'May and I watched between the hours of 3:09 and 4:00 A. M., during which period we counted 31 meteors, nearly all showing by their course that they were Leonids. The radiant point was near the center of the circle. We did not try to record the magnitudes.

No.	Hr.	Min.	No.	Hr.	Min.	No.	Hr.	Min.	No.	Hr.	Min.
1	3	09	9	3	27½	17	3	36½	25	3	46
2	3	09	10	3	29	18	3	37	26	3	50½
3	3	16	11	3	30	19	3	40	27	3	52
4	3	19	12	3	30½	20	3	42	28	3	56
5	3	22	13	3	31	21	3	42½	29	3	57
6	3	24	14	3	32	22	3	43	30	3	59
7	3	25½	15	3	33	23	3	43½	31	4	00
8	3	27	16	3	36	24	3	44			

Summary for Nov. 14.—On the evening of Nov. 14 more careful observations were made by Mr. Dean and myself, Mr. O'May keeping record. The observations extended from 12:26 to 2:26 A. M., in which time 112 meteors were seen. Most, if not all of, these, were identified as Leonids. Seven were probably of the first magnitude. The greatest fall was between 2:06 and 2:16, during which nineteen fell. The greatest number seen in one minute was five. Below is the table giving time, magnitude and number:

No.	Hr.	Min.	Mag.	No.	Hr.	Min.	Mag.	No.	Hr.	Min.	Mag.
1	12	26	3	39	1	21½	6	77	1	55	4
2	12	30	2	40	1	22	2	78	1	56	5
3	12	30½	1	41	1	22½	1	79	1	56¼	6
4	12	34	1	42	1	23½	4	80	1	57	6
5	12	35	1	43	1	24	2	81	2	02	6
6	12	35½	1	44	1	25	3	82	2	02½	6
7	12	35¾	4	45	1	27	5	83	2	03½	6
8	12	36	3	46	1	28½	4	84	2	04	4
9	12	44	4	47	1	29	6	85	2	06	2
10	12	45	4	48	1	30	4	86	2	06½	3
11	12	45	5	49	1	31	2	87	2	06¾	4
12	12	45	3	50	1	31½	3	88	2	07	3
13	12	48	4	51	1	32	3	89	2	08	6
14	12	48½	4	52	1	35½	6	90	2	08¼	5
15	12	50½	2	53	1	36	3	91	2	08½	6
16	12	51	4	54	1	36½	5	92	2	08¾	5
17	12	51½	6	55	1	39	4	93	2	09	3
18	12	52½	3	56	1	39½	4	94	2	09¼	5
19	12	53	4	57	1	39¾	3	95	2	09½	6
20	12	55	6	58	1	40	4	96	2	09¾	6
21	12	56	3	59	1	41	3	97	2	10	4
22	12	57	2	60	1	42	4	98	2	10¼	3
23	12	58	2	61	1	43	3	99	2	11	4
24	12	59	3	62	1	44	6	100	2	13	6
25	12	59	3	63	1	44½	6	101	2	14	3
26	12	59½	5	64	1	45	5	102	2	15	4
27	12	59¾	2	65	1	47	3	103	2	15¼	3
28	1	04	5	66	1	49	4	104	2	16	2
29	1	05	5	67	1	49½	3	105	2	18	4
30	1	07	3	68	1	50¼	0	106	2	19	2
31	1	08	2	69	1	50½	4	107	2	19¾	6
32	1	14	4	70	1	50¾	6	108	2	21	4
33	1	15	6	71	1	51	5	109	2	22	5
34	1	15¼	6	72	1	52	6	110	2	22	6
35	1	19	6	73	1	52½	6	111	2	25	4
36	1	20	1	74	1	53	5	112	2	25½	3
37	1	20½	6	75	1	54	3				
38	1	21	5	76	1	54¼	4				

Observation closed at 2:26.

I felt well paid for my watching and am sorry that the full moon will interfere next year.

P. W. JENKINS.

Leonid Meteors observed at Mt. Holyoke College Observatory.—Miss Elizabeth M. Bardwell, Director of Mt. Holyoke College Observatory, sends a chart of the Leonids observed on the morning of Nov. 15, containing the trails of 42 meteors. The following notes are appended:

"The bright meteor represented by the short broad line near δ Leonis was seen at $2^h\ 58^m$ A. M. and left a trail which was visible for 2½ minutes.

"The broad trail, starting near η Ursæ Majoris at $3^h\ 15^m$ A. M., persisted longer than most of the others.

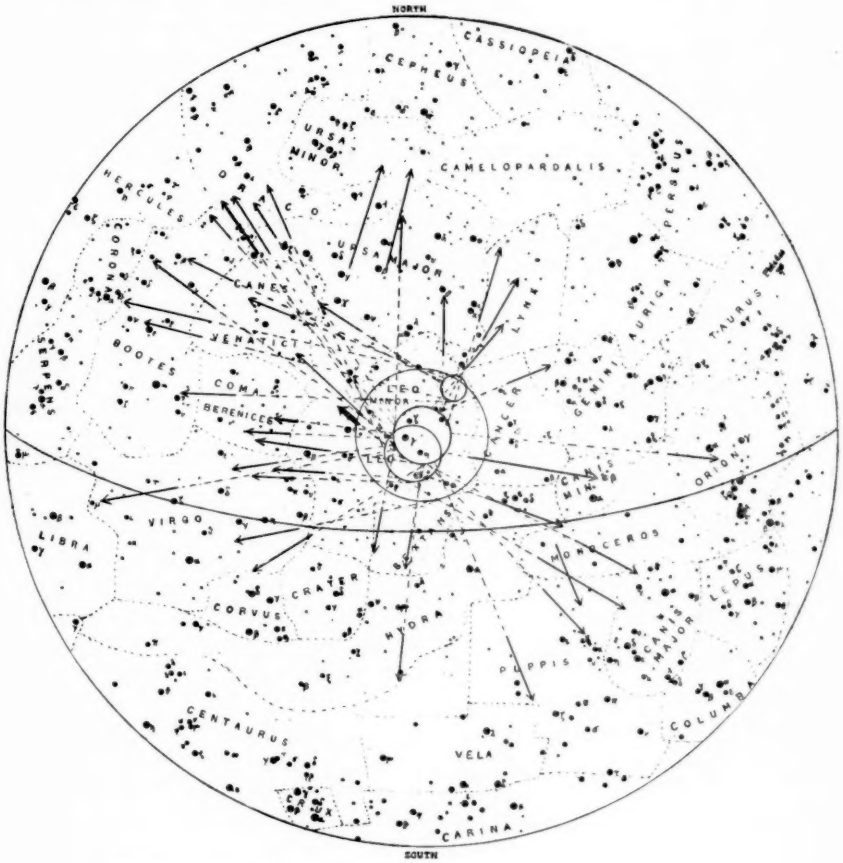


CHART OF LEONID RADIANT FROM OBSERVATIONS AT MOUNT HOLYOKE OBSERVATORY NOV. 15, A. M.

"The short broad trail in Coma Berenices persisted 20 seconds. The meteor appeared at $4^h\ 15^m$ A. M."

This chart seems to confirm what has been said by several observers, that the radiant appeared to cover a large part of the constellation Leo. A small proportion of the trails produced can be made to pass through the small radiant near the center of the Sickle. It is difficult to differentiate between the meteors recorded and, if we include all but 3 or 4 as true Leonids, it requires a circle about 30° in diameter to cover the radiant. Perhaps the observations may best be satisfied by two radiants, one in the extreme northeast part of Leo indicated by the small circle upon the chart and another having its center near η Leonis.

H. C. W.

Leonids Observed at Carlisle, Pa.—By favor of Edgar N. Fought, special representative of the *Daily Herald* of Carlisle, Pa., we are able to present the following report of observations of the Leonids at Carlisle:

On the night of November 14-15 a company of twenty-nine persons, including Professor W. W. Landis, of Dickinson College, and a part of his Astronomy class, assumed a favorable location a short distance from Carlisle to make observations of the Leonid meteors. Notwithstanding the occasional intervention by clouds, the display proved intensely interesting throughout. Up to midnight on November 14th twelve were seen; from 12:00 to 1:00 o'clock, 34; from 1:00 to 2:00 o'clock, 64; from 2:00 to 2:36 o'clock, 52. (At this time the party wended its way homeward, and several more meteors were observed en route.) From 3:00 to 3:15 A. M., 17 were recorded. Observations ceased at that time, the maximum having been unmistakably witnessed.

Many of the meteors exceeded in brilliancy stars of the first magnitude and called forth repeated expressions of mingled *surprise* and admiration. The phosphorescent streaks, so long associated with the Leonids, were seen in all their splendor and some were as much as thirty seconds in duration. In the entire observation, about five hours, there were few meteors observed which were not distinctly Leonids. The radiant was situated about the center of the constellation, Leo, and was well defined. Much attention was directed toward the bright streaks which formed a characteristic feature. The concensus of opinion was that the prevailing colors were yellow and orange for the nuclei, and pale green for the streaks. During the height of the display there was no intrusion by moonlight and our location was such as to afford ample protection from the glare of electric lights, so that, in its entirety, the observation was crowned with very auspicious conditions. Despite careful listening no audible sound such as that of a distant explosion could be detected after the disappearance of the finest meteors.

Cloudy weather effectually stopped all attempts at observing the display announced from Andromeda on November 23rd, but one fine one from this constellation was witnessed on November 27th by the writer. This one was seen just above the horizon about 10:02.

On the morning of Dec. 2nd, shortly before 7:00 o'clock, Z. T. Miller, a reputable resident of this community, beheld in the western sky a meteor of dazzling brilliancy. It passed in an arched path from southwest to northwest and appeared to explode just before it disappeared. What makes the meteor worthy of more than ordinary note, is the fact that it was daylight at the time, and further that it was just a few minutes before sunrise. The same meteor was seen at Newville and Hagerstown, two towns on a line southwest of this place.

Last Saturday night, December 10th, quite a number of meteors were seen

radiating from Gemini. The display lasted about three and one-half hours and upwards of 100 were seen. While many possessed extreme brightness, they lacked the streaks which characterized the Leonid display. Several more from Gemini were seen on Sunday night. In the Saturday night shower the writer saw ten from 11:40 until 1:25 A. M. EDGAR NEWTON FOUGHT.

CARLISLE, Pa.

The Dial of Ahaz.—I have read with much interest Dr. Morrison's ingenious interpretation of this mysterious and obscure passage of scripture. Taken as a whole, it is an instructive paper, but his conclusion that no miracle was performed, but simply the shadow of the gnomon going backward, a phenomenon of daily occurrence, is in my opinion both unscriptural and untenable. I will give my views as briefly as is consistent with clearness, which, as far as I know, is unlike any of the many heretofore advanced. The doctor adopts the erroneous translation of the Authorized Version, measuring the backward motion of the shadow by degrees. Degrees of what? The value of a degree of a circle depends on its size. Does the expression convey to the reader the amount of the retrograde motion of the shadow?

The Revised Version says steps instead of degrees which means something tangible, but still retains the meaningless words, "by which it had gone down." The question asked Hezekiah was, whether he would have the shadow go forward (not down) ten steps or backward ten steps?

Doubtless a large assembly had gathered at the dial to witness the miracle, and it would have been the height of folly on the part of Isaiah, to attempt to deceive the people by witnessing a phenomenon of daily occurrence and palm it off as a miracle. The people must have been from childhood familiar with the workings of the dial, for it could not be hidden under a bushel.

When the miracle was performed, Ahaz had been dead thirteen years. How long it had been in his possession during his life is unknown. Any object capable of casting a shadow would have answered the purpose as well as the style of the dial, but the event was of tremendous import, and therefore it was important that a conspicuous, and familiar locality be chosen, and a well known object be selected to cast the shadow, hence the selection of the style of the dial.

Now my version of the account is that it should read about as follows, which means something definite and is not opposed to scripture but in touch with it: And Isaiah, the prophet, cried unto the Lord, and he brought the shadow backward ten steps or (paces) as measured from the dial of Ahaz, or some thirty feet, allowing three feet to a step.

I contend that it was a miraculous performance, and must have occurred just before sunset, and produced by excessive refraction by the air. The Creator could easily cause a vast accumulation of air in the vicinity of the Sun, or, increase the index of refraction, or both, thereby producing the miracle as described in II Kings chapter XX., verse 11, but poorly translated

ECHO MOUNTAIN, Cal., Dec. 13, 1898. LEWIS SWIFT.

"Phenomena yet Unexplained."—On page 589 of POPULAR ASTRONOMY for December, Professor Swift calls attention to a "Phenomenon yet unexplained," and states that it is not seen elsewhere than in southern California.

I have seen the same phenomena repeatedly in different parts of the state and the explanation seemed so simple and so obvious that it never occurred to me that it would be worth recording.

I have seen it in the Sierras, in the neighborhood of Blue Cañon in Placer County, in fact, the place takes its name from the same blue haze which is seen in the San Gabriel Valley. I have seen it repeatedly at Mt. Hamilton; also on one occasion from the top of Mt. Diablo, just previous to sunrise. In this case the "blue belt" set as the sun rose. Those of us who transact our business in San Francisco, and who cross the Bay daily for that purpose, see it nearly every clear evening, especially at this time of the year when we cross about sunset, and the phenomenon is very marked when the sun sets in a clear western sky with a bank of clouds in the east. I remember distinctly, on one such occasion, seeing the "blue belt" broken by an exaggerated profile of the San Francisco hills, which lay between the belt and the sun. In this case a cloud bank was low and close overhead.

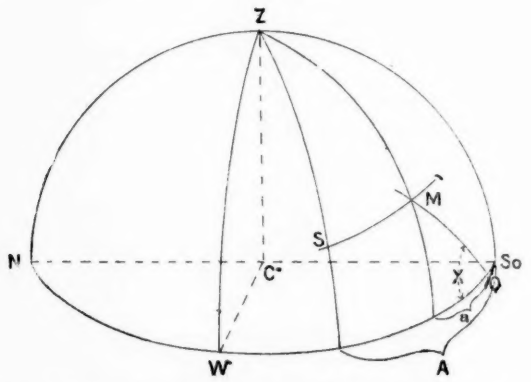
It seems to me that no spectroscopic investigation is required to determine that it is a simple case of the projection of the earth's shadow upon a cloud bank or upon atmospheric dust, and not a case of the colors being refracted out of their natural order. The blue belt which is seen is merely a shadow, and the blue of the upper end of the spectrum is invisible because it is merged in the blue sky overhead.

Professor Swift appears to have observed accurately, for he says that the red and blue belts do not seem to mingle as do the red and yellow, which would be the case if the blue belt was due to a shadow and not to refraction. It seems as if the observation of this fact ought to suggest the explanation.

OAKLAND, Cal., Dec. 10, 1898. ALLEN H. BABCOCK.

The Angle of the Lunar Cusps with the Horizon at any Place.—The solution of the problem* of determining the angle made with the horizon of any place by a produced line joining the cusps or horns of the Moon.

In solving this problem the latitude and longitude of New York City were used.



The figure shows the situations of the bodies before the Sun has set. The mathematical conditions to be satisfied will be the same as though the Sun had set.

* This solution is by F. Elcharwich, Chief of Bureau of Equipment, Washington, D C., kindly sent us by Rev. Geo. W. Dubois, Essex, N. Y.

Let C = the observer's position on the Earth, Z = the zenith, N = the north point, So = the south point, W = the west point, S = the Sun, M = the Moon.

Draw a line from the Sun to the Moon, $S - M$. This will represent the Sun's rays, and projected upon the celestial sphere will describe the arc of a great circle, $S - M$, as represented in Fig. 1. The line joining the cusps of the Moon will be at right angles to the line $S - M$ and be projected in the arc $M - O$ of Fig. 1. The angle $M - O - W$ is the angle required. Call this angle X.

Latitude selected = 40° 44′ 00″ =
Longitude " = $4^h\ 55^m\ 55^s$
Problem.—To find X for any chosen time.
Time chosen = 1895, March 28th, 8 P. M.
As the astronomical day begins at noon it will be 1895, March $28^d\ 8^h\ 0^m\ 0^s$.
To reduce Greenwich time add 5 hours.
Greenwich time = 1895: March $28^d\ 13^h\ 0^m\ 0^s$.
Long. of observer = 4 55 55
Local mean time = '95: March $28^d\ 8^h\ 4^m\ 5^s$

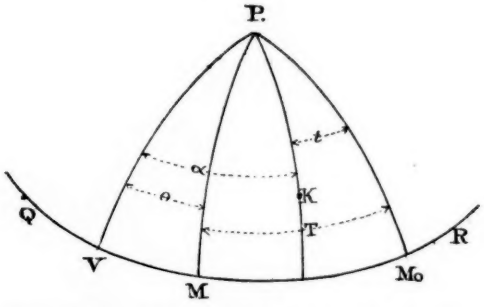
Find right ascension and declination for Sun and Moon at this time.

Let α' = Moon's right ascension, δ' = Moon's declination.
" α = Sun's " " δ = Sun's "

From American Ephemeris, 1895,

$$\alpha' = 2^h\ 17^m\ 44^s.39, \quad \delta' = 17°\ 48'\ 59''.7$$
$$\alpha = 0\ \ 29\ \ 44\ .35, \quad \delta = \ \ 3\ \ 12\ \ 49\ \ .0$$

The next step is to determine the hour angles of the Sun and Moon.



P = pole, QR = equator, PMo = noon meridian, PM = observer's meridian, K = body in question, t = hour angle, α = right ascension of body, θ = right ascension of mean Sun.

$$\alpha + t = \text{sidereal time} = \theta + T$$
$$t = \theta + T - \alpha$$

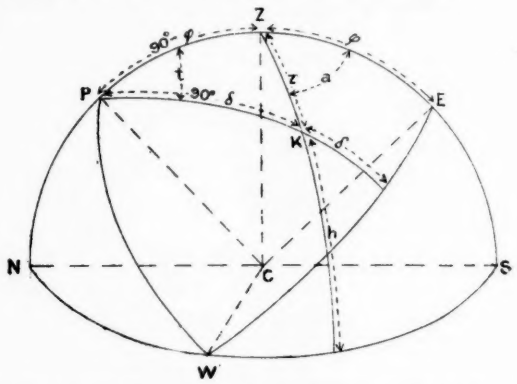
For 1895: March $28^d\ 8^h\ 04^m\ 05^s$

$$\theta = 0^h\ 24^m\ 44^s.32$$
$$\theta + T = 8\ \ 28\ \ 49\ .32$$

$8^h\ 28^m\ 49^s.32 - 2^h\ 17^m\ 44^s.39 = 6^h\ 11^m\ 4^s.93 = 92°\ 46'\ 14'' = t'$ = hour angle of Moon.

$8^h\ 28^m\ 49^s.32 - 0^h\ 29^m\ 44^s.35 = 7^h\ 59^m\ 4^s.97 = 119°\ 46'\ 14''.6 = t$ = hour angle of Sun.

We have now given the hour angle and declination of the Sun and Moon and we wish to transform these coördinates to azimuth and altitude.



P = pole, Z = zenith, K = the position of any heavenly body, φ = latitude of observer.

We know the value of $90 - \varphi$, $90 - \delta$, and t. Therefore the triangle PZK can be solved. We wish z = zenith distance and $180° - a$. From these h and a can be obtained. This problem is worked out in Chauvenet's Astronomy, Vol. I, p. 31, prob. 14.

After some substitutions the resulting equations are

$$\tan M = \frac{\tan s}{\cos t}$$

$$\tan A = \frac{\tan t \cos M}{\sin (\varphi - M)}$$

$$\tan z = \frac{\tan (\varphi - M)}{\cos A}$$

A = azimuth.

	Sun.	Moon.
$\tan \delta$	8.74932	9.50703
$\cos t$	− 9.69594	− 8.68428
	− 9.05338	
$\tan M$		− 0 82275
M	− 6° 27′ 06″	− 81° 26′ 48″
φ	+ 40 44 00	+ 40 44 00
$\varphi - M$	47 11 06	122 10 48
$\tan t$	− 0 24258	− 1.31529
$\cos M$	9 99724	9 17240
$\csc (\varphi - M)$	0.13456	0.07247
$\tan A$	− 0.37438	− 0 56016
A	112° 53′ 40″	105° 23′ 36″
$\tan (-M)$	0 03316	− 0.20118
$\cos A$	− 9.58999	− 9.42398
$\tan z$	− 0.44317	0.77720
Z	109° 49′ 13″	80° 31′ 02″
	Z	z

These values of Z and z should be corrected for parallax. For the Sun it is practically nothing. For the Moon use the formula.

$\pi = \pi_0 \sin z$, in which $\pi_0 = 56'\ 5''.9 = 3365''.9$

$\log \sin z$	$= 9.99402$	$z =$	$80°\ 31'\ 02''$
$\log \pi_0$	$= 3.52710$		$55\ \ 20$
$\log \pi$	$= 3.52112$	$z =$	$81\ \ 26\ \ 22$
π	$= 3320 = 55'\ 20''$	$Z =$	$109\ \ 49\ \ 13$

$A - a = 7°\ 29'\ 07''$

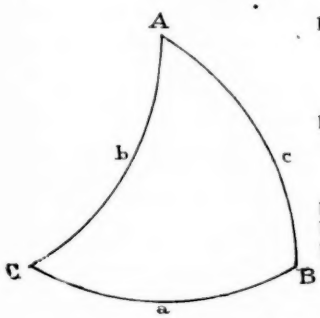
The last three values give us the following triangle.

A = zenith, B = Moon, C = Sun, $b = 109°\ 49'\ 12''$, $c = 81°\ 26'\ 22''$, $BAC = 7°\ 29'\ 07''$.

$$\text{Sin } A \cot B = \sin c \cot b - \cos c \cos A$$

Let $M = 180 - B$

or $$\sin (A - a) \cot M = -\sin c \cot b - \cos c \cos (A - a)$$



$\log - \sin c = -9.99514$
$\quad \cot b = \ \ 9.55675$
$-9.55189 = .35634$

$\log \cos c = -9.17276$
$\log \cos (A - a) = \ \ 9.99629$
$-9.16905 = .14761$
$.50395 = \text{sum}.$

$\log \sin (A - a) = \ \ 9.11485$
$\log (\text{sum}) = \ \ 9.70239$
$\log \tan M = +9.41246$

In Fig. 1 let $PMO = U = 90° - M$

$\log \cos M = 9.98596$
$\log \sin z = 9.99513$
$\log \cos X = 9.98109$
$X = 16°\ 47' =$ the required result.

BOOK NOTICES.

Differential and Integral Calculus.--We are in receipt of a copy of the revised edition of the Elements of the Differential and Integral Calculus by James M. Taylor, Professor of Mathematics at Colgate University; published by Messrs. Ginn and Company, Boston, Mass.

The important points in Professor Taylor's revision, which the eye of the teacher of this delightful branch of mathematics will quickly catch, is an attempt to present in their unity the three methods now most commonly used in teaching the elements of the Calculus, viz.: the the method of Limits, of Infinitessimals and the method of Rates. Heretofore, authors have mainly adopted one or another of these different ways of explaining and illustrating and even proving the principles of the science and, then, more or less briefly refer to the other methods, as in use by other texts and adopted by them for the same purpose. In this particu-

ar, the author before us has given more attention to the principles underlying these methods and sought to bring out the real meaning of each and apply the same in the best way to the various problems that come especially in the domain of Calculus. This is a task that an author might well hesitate to undertake in an elemental book, but, nevertheless the purpose to master this important part in the theory of the Calculus is a most worthy one, and ought to give the student clearer ideas of the troublesome points he will meet in passing from discontinuous to continuous number in the theoretical as well as the practical side of the study. The author uses the method of Rates so as not to involve "the foreign element of time," by assuming the rate of any variable as the unit of rates. When the problem of rates is familiar, the solution by the method of Limits or Infinitessimals is employed; making the theory of Infinitessimals a part of the theory of Limits, on the grouhd that the limit of the ratio of Infinitessimals is the same thing as the common limit of zero reached by the other method.

For an elementary text the work is full, general and complete with many figures and examples for illustrating its principles. The typhographical part of it is excellent, as is always true of books by Messrs Ginn & Co. They know how to make a text-book.

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